Irrigation Scheduling Strategies for Limited Irrigation Conditions

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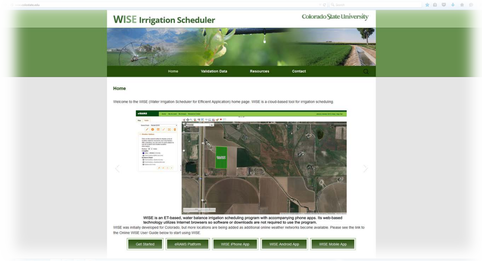

Rationale

•When precipitation and irrigation water cannot meet seasonal crop water requirements (limited irrigation), the amount and timing of irrigations become critical decision factors for managing crop water stress.

•The soil water stress coefficient (Ks) or crop water stress index (CWSI) can be used to estimate actual crop evapotranspiration (ETa) for scheduling of limited irrigations.

•.Quantifying crop ETa and water stress throughout the season can help estimate the amount and timing of irrigations at different growth phases of the crop.

Objective

Evaluate the performance of the soil water stress coefficient (Ks) and crop water stress index (CWSI) techniques for estimating corn (*Zea mays, L.*) ETa for irrigation scheduling under water stressed conditions.

Methodology

• At Fort Collins, CO, corn (Pioneer P9305AM) was grown in 2015 under 3 irrigation treatments: (a) Opportunity irrigation (25 mm/week); (b) Limited irrigation (no irrigation from V5 to VT growth stages; otherwise same as opportunity); (c) drought (only 1 irrigation, 13 mm, on 7/16/2015). Soil was strip-tilled and corn was irrigated with a linear move sprinkler system (Fig. 1a). Irrigations were not applied until 7/16/2016 because of sufficient rainfall (148 mm) and soil moisture prior to this date.

• Soil water content (mm^3/ mm^3) in the root zone was measured weekly using a neutron moisture meter (0 – 1500 mm depth, at 300 mm increments). Weekly observed ETa was calculated by water balance (DeJonge, et al., 2011).

• Daily ETa (mm/d) was estimated as: ETa = ETr * Kc * Ks; or

ETa = ETr * Kc * (1 – CWSI)

where ETr is tall (alfalfa) reference crop ET; Kc = crop coefficient.

Ks = (TAW – D) / (1 – MAD) TAW; Ks = 1 if D < TAW * MAD (Allen et al., 1998)

where TAW is total available water in root zone (mm), D is root zone depletion or deficit (mm), MAD is management allowed depletion (fraction).

CWSI = (dT – dTl) / (dTu – dTl) (Jackson et al., 1988)

where dT = measured temperature difference (°C) between canopy and air temperatures, and dTl and dTu are crop-specific lower and upper limits of dT (Idso, 1982; Idso et al., 1981)

• Daily ETr and rainfall was obtained from the Colorado Agricultural Meteorological Network (www.coagmet.com); Kc, Ks, and ETa were calculated by the Water Irrigation Scheduler for Efficient Application (http://wise.colostate.edu/; Andales et al., 2014).

• dT was measured near noon on selected dates using a Cropscan MSR5 multispectral radiometer (Fig. 1b). dTu and dTl were calculated as linear functions of vapor pressure deficit (VPD) (Idso, 1982; Idso et al., 1981) and CWSI was calculated.

(c) Seasonal water balance components

Treatment	ETa, mm	P, mm	Irr_g, mm
Opportunity	418	168	279
Limited	352	168	152
Drought	285	168	13

P = precipitation; Irr_g = gross irrigation

Figure 1. View of the corn plots under opportunity irrigation, limited irrigation, and drought (a); and operation of the Cropscan MSR5 multispectral radiometer (b). Relevant seasonal water balance components (5/15/2015 – 9/17/2015) are also given (c).

Preliminary results

• Daily corn ETa estimated by WISE using the Ks technique showed expected responses for the 3 irrigation treatments (Fig. 2): the same ETa amounts before 7/16/2015 when rainfall kept up with ET requirements; lowest ETa values for limited irrigation treatment when irrigations were withheld (7/16 – 8/5) and recovery of ETa when irrigations resumed (8/6 onwards); lowest ETa values under drought after 8/5/2015. The daily Ks curves showed no stress (Ks = 1) before 7/16/2015 and stress thereafter (Fig. 3).

• Cumulative corn ETa values estimated by WISE (using Ks) were generally over-estimated compared to observed values calculated from weekly water balance (Fig. 4). This indicated that Ks values under-estimated the water stress. However, assumed values of Kc can also be a source of error. The index of agreement (d) between modeled (WISE) and observed cumulative ETa ranged from 0.80 to 0.97, which seem acceptable for irrigation scheduling. The smallest root mean square deviation (RMSD) was obtained from the limited irrigation treatment.

• The (1 – CWSI) values were expected to correspond well with Ks values, but they showed poor agreement (Fig. 5). The canopy temperatures obtained from the nadir MSR5 readings were contaminated with background soil temperature (due to sparse canopies or leaf curling; Fig. 1b) and need corrections.

Summary

- The Ks technique under-estimated water stress, but showed good overall agreement (d = 0.80 – 0.97) of cumulative ETa with weekly observed values.
- The field method for measuring canopy temperature will be improved to eliminate background contamination with soil temperature. Further evaluation of the CWSI technique to estimate ETa will be done.
- Data from 2 additional growing seasons (2014 and 2016) will be analyzed to evaluate how the Ks and CWSI techniques perform under varying weather conditions.

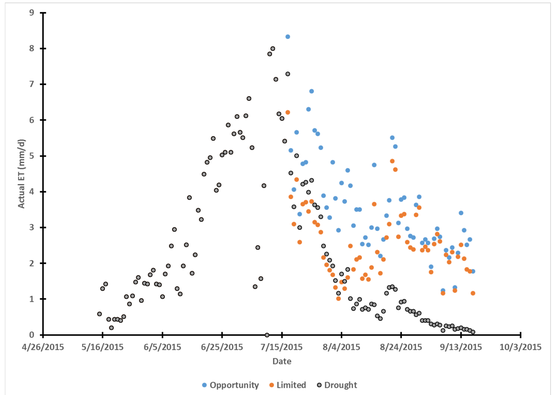

Figure 2. Daily corn ETa (mm/d) estimated by WISE using the Ks technique for quantifying water stress under 3 irrigation treatments.

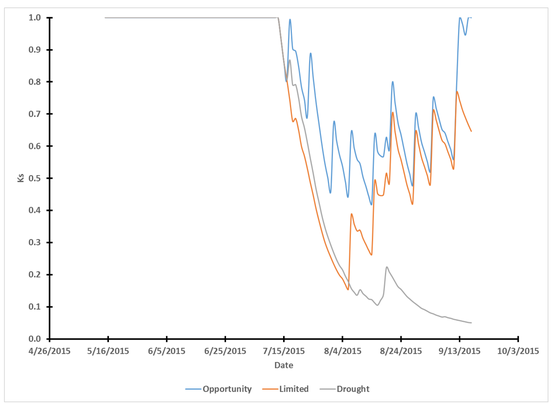

Figure 3. Daily Ks values estimated by WISE for corn under 3 irrigation treatments in 2015.

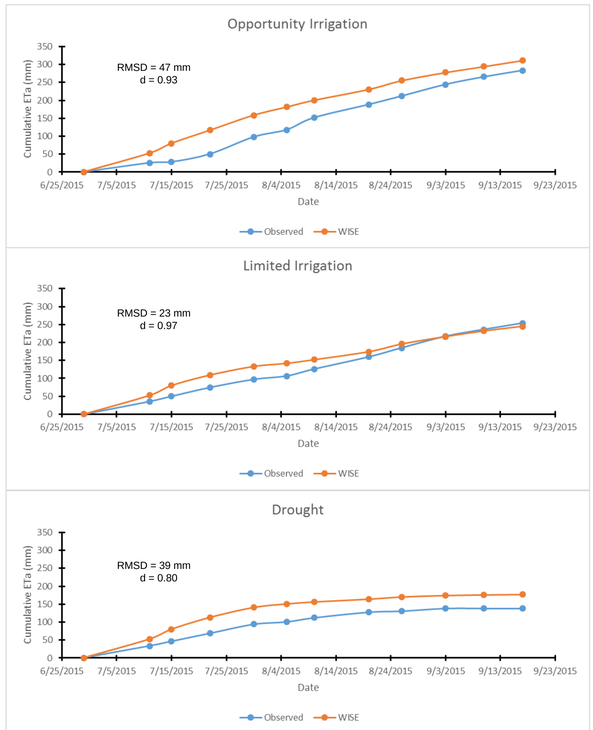

Figure 4. Observed and WISE estimated cumulative corn ETa (mm) for the period 6/29/2015 to 9/17/2015 under 3 irrigation treatments. (RMSD = root mean square deviation; d = index of agreement)

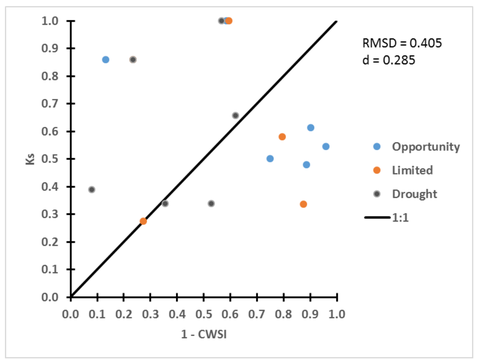

Figure 5. Comparison of Ks and (1 – CWSI) on dates when CWSI was measured for corn under 3 irrigation treatments (7/1 – 9/9/2015).

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Acknowledgement

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