

FELLOWSHIP SUMMARY REPORT

OECD Co-Operative Research Programme

Biological Research Management for Sustainable Agricultural Systems

Crop Stress Response Calibrations for Improved Water Use Assessments under Deficit Irrigation

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Host Institution: Centro Regional del Estudios del Agua, Universidad de Castilla-La Mancha
Host Collaborator: Alfonso Domínguez Padilla
Fellowship Dates: 8 Mar 2017 – 21 Jun 2017

Consent Statement: I give consent for the posting of this report on the Co-operative Research Programme's website.

1. What were the objectives of the research project? Why is the research project important?

The objectives of the proposed study were to (i) calibrate and evaluate stomatal and senescence stress response functions using existing field studies of deficit irrigated maize (ii) evaluate three soil water sensor technologies in estimating soil water depletion and potential deviations in predicting transpiration using stress response functions of AquaCrop in an irrigated field study carried out in Albecete and (iii) calibrate and validate AquaCrop for maize using the developed stress response functions.

A major weakness of crop models is that water use under moderate to severe irrigation deficits is poorly estimated thereby contributing to uncertainty in water allocations required to optimize productivity when water is limiting. These uncertainties largely arise from water stress functions that regulate transpiration and biomass accumulation. A further difficulty in calibrating these models is the degree of uncertainty in estimating soil water depletion levels and their impact on stress response and predicted transpiration. Accurate soil water content monitoring is paramount to assessing crop water use and the associated stress responses which cannot be evaluated using weighing lysimeters because of the inability to resolve soil water depletion only within the rooting zone. This research will be used in the improved assessment of crop water use required to evaluate optimal deficit irrigation strategies and allocation of water resources both in Central Spain and the southern U.S. Great Plains. These model driven assessments will aid producers, irrigation cooperatives, and water districts in these regions on how to optimize water allocations to generate the maximum economic benefit at acceptable production risks.

2. Were the objectives of the fellowship achieved?

The first two objectives have been partially achieved and the third objective is in progress. Multiple cropping year data from several field studies is currently being analysed to address objective (i) and the extensive data set of soil moisture measurements pertaining to objective (ii) is also being analysed. Refinements of the modelling of stress response is also ongoing.

3. What were the major achievements of the fellowship? (up to three)

- (i) Development of an algorithm to utilize soil water content data in the calibration of stress response in maize throughout a growing season. This involves accounting for root elongation during the growing season as well as changes in soil profile water associated with soil water content measurement errors.
- (ii) Development and initial evaluation of a scaled logistics stress response function that has properties associated with a gradual transition from non-water stressed to water stressed as soil water depletion increases. Initial evaluation of this response function for maize does not improve evapotranspiration estimates under significant water stress compared with the standard FAO-56 linear response function for non-standard conditions.
- (iii) In a field evaluation of soil water sensor technology in Albacete, Spain, only the Acclima TDR-315 soil water sensor was able to measure soil water contents of sufficient accuracy to properly resolve the soil water balance throughout the growing season (garlic). Water contents estimated using the capacitance probe were strongly sensitive to temperature whereas the granular matrix sensors had poor sensitivity at potentials less than 40 cbars.

4. Will there be any follow-up work?

Follow-up work will consist of: (i) A continuation of the calibration and evaluation of stress response functions using existing field studies of deficit irrigated maize and incorporate these calibrations into crop water use models MOPECO and AquaCrop. The calibrated models will be used to evaluate optimal deficit irrigation strategies for maize. (ii) Completion of the analysis of the soil moisture field data collected in Albacete, Spain to compare sensor performance, evaluate soil water balance and evapotranspiration of garlic during the growing season, and compare soil water balance approximations with mini-lysimeters installed in the experimental field.

Several publications are envisaged that would comprise the calibration of the stress response function, use of the calibrated models to evaluate optimal deficit irrigation strategies, and soil

water sensor comparisons and evaluations. The articles will be prepared and submitted to journals within the coming year to two years.

This fellowship will likely be the start of collaboration between USDA-ARS, Bushland and CREA, Universidad de Castilla-La Mancha beyond the activities associated with this fellowship.

The research may result in the development of novel algorithms to utilize soil water sensor data in calibrating crop water use models.

5. How might the results of your research project be important for helping develop regional, national or international agro-food, fisheries or forestry policies and, or practices, or be beneficial for society?

Water allocation decisions will become increasingly more difficult with increasing competition and localized shortages in the coming years. This research will strengthen the scientific knowledge and process models required by agricultural producers, irrigation cooperatives, water districts, and policy makers to assess the influence of water deficits on yield and make informed decisions on how to allocate water to optimize productivity and net margins at acceptable risks. Poor allocation decisions can result in inefficient use of water for crop production and greater production risks and, over the long-term, influence the solvency of irrigated farms and food security in developing nations.

6. How was this research relevant to:

The objectives of the CRP: This research will strengthen the scientific knowledge and process models required by agricultural producers, irrigation cooperatives, water districts, and policy makers to assess the influence of water deficits on yield and make informed decisions on how to allocate water to optimize productivity and net margins at acceptable risks.

The CRP research theme: The research focused on synthesizing and improving models useful for evaluating strategies for optimizing agricultural water productivity required for sustainable water management and identifying irrigation practices that could reduce water consumption. These goals are central to the Water component of Theme I “Managing Natural Capital for the Future”

7. Satisfaction

Did your fellowship conform to your expectations? Yes. To a large degree, this is dependent on involvement of the host collaborator and the support of the host institution, which in my case was exceptional.

Will the OECD Co-operative Research Programme fellowship increase directly or indirectly your career opportunities? Please specify. The OECD Co-operative Research Programme has undoubtedly increased my career opportunities. The experience overseas working with scientists of similar or complementary disciplines permitted a great opportunity to develop closer scientific collaborations and an excellent learning experience that facilitated a broader understanding of the science and societal constraints associated with allocation of water for irrigation.

Did you encounter any practical problems? Yes. The requested term of the fellowship was shortened by a month (ending June 21, 2017) which was impractical for the study because the garlic was harvested at the end of June and the sensors were removed in early July. Prior to the beginning of the fellowship, I sought and obtained my agency’s approval to extend the stay to 19 July 2017.

Please suggest any improvements in the Fellowship Programme. None.

8. Advertising the Co-operative Research Programme

How did you learn about the Co-operative Research Programme? Through a colleague.

What would you suggest to make it more “visible”? The programme is currently quite “visible” compared to five years ago.

Are there any issues you would like to record? None