Principle Investigator:
James P. Bordovsky

Co-Principle Investigator(s):
James Wall, Dana Porter, Keith Biggers, Mark Kelley, Srinivasulu Ale

Title:
Timely Management of Limited Irrigation Crops in Texas Using an Empirically-based Model and Innovative Information Dashboard Technology

Priority Areas:
• Sustainable practices that apply to agricultural applications for field crops
• Advances and deployment of technologies with linkages to rural initiatives in water conservation and irrigation management

Project Summary:
Irrigated cotton on the Texas High Plains (THP) is grown on approximately two million acres with the vast majority irrigated by low pressure center pivots using water from a non-replenished water source (Ogallala Aquifer). One of the most notable findings of recent cotton irrigation experiments was that large early-season irrigations, those meant to increase root zone water for later seasonal use, were only marginally effective in increasing final cotton yields. By means of this project, DIEM, Dashboard for Irrigation Efficiency Management, was developed to explain and make actionable these and other research findings. Using a simple interface, DIEM integrates localized farm and environmental data, leverages a computational model based on prior water use efficiency field experiments, and outputs a season long irrigation schedule that can be visualized and analyzed to support enhanced understanding and decision making. DIEM provides analytic displays, the ability to evaluate different “what-if” scenarios, and the generation of reports based upon the assimilated data/information. As the crop season progresses, new environmental and irrigation data can be incorporated to “re-optimize” the remaining seasonal irrigation prescription based on projected available water, water use efficiencies, and yield scores. This re-optimization can be monthly, weekly, or daily, depending on user need.

Approach:
As a means to incorporate and disseminate recent and new field research findings for end user decision making, a customizable information dashboard was built by leveraging a highly robust technology called the Information Dashboard Framework (IDF). IDF was developed by researchers at the Texas A&M Engineering Experiment Station’s Texas Center for Applied
Technology (TCAT) in coordination with Texas A&M AgriLife’s Institute for Infectious Animal Diseases (IIAD). This capability was combined with existing in-house visual analytic tools to create an integrated irrigation information dashboard. IDF facilitates the collection, aggregation, filtering, processing (including data/information fusion), and the tailored presentation of data/information from multiple disparate data sources such as weather and soil databases, applications such as crop and economic models, and sensors both existing or proposed.

The resulting information dashboard, DIEM, was developed to be unlike other irrigation management systems that simply signal when to start and stop irrigations. Rather, DIEM evaluates season long relationships among available water quantities, timing of water availability (including rain), and crop water needs to determine yield and water-use efficiency (WUE) “scores” for a specific field. These “scores” are then used as metrics to improve irrigation distribution. DIEM integrates localized farm and environmental data, leverages a computational model based on the aforementioned WUE field experiments, and outputs a season long irrigation schedule recommendation. As the crop season progresses, new environmental and irrigation data can be incorporated to “re-optimize” the remaining irrigation prescription. This re-optimization can be once a month, once a week, or once a day, depending on end user need or preference. As part of the initial technology development, outside reviewers (including farmers, county and integrated pest management (IPM) agents) have provided positive feedback and future direction for DIEM improvements.

Goals and Outcomes Achieved:

• Identification of existing information/data sources,
  ▪ Completion of soil water methodology for input into the framework,
  ▪ Completion of the design of overarching model that supports evolution from generalized to more specific information/data inputs,
  ▪ Calibration and evaluation of the DSSAT (CSM-CROPGRO-Cotton) model using the water limited constraints of the Southern High Plains,
• Validation of elements of the experimental "water saving" protocol on a producer scale under different production conditions,
• Completion of the initial design, development, and deployment of a framework for an irrigation information dashboard (DIEM),
• Evaluation of DIEM by selected end users (producers, crop advisors) for further development.

Beneficiaries of the Research:

The direct beneficiaries of this project are:
• Texas South Plains cotton producers and crop advisors.
• Others:
  ▪ Local/Regional USDA-NRCS and associated technical service providers,
  ▪ Groundwater conservation districts,
  ▪ USDA-Risk Management Agency and crop insurance providers,
  ▪ Landowners and others directly benefitting from improved farm profitability and farm-level sustainability,
  ▪ Ag lenders (bankers),
Any entity benefiting from prolonging irrigated agricultural or diverting water from irrigation to other uses including irrigation and farm equipment industries, seed and farm chemical industries, and all governmental units that depend on irrigated agriculture as a major portion of their tax base.

Lessons Learned/Impacts:
Agricultural producers indicated this tool would be very useful to them. They were very positive about the tool, and they were very outspoken about options and changes they would like to see. Specific aspects of the tool they liked include:

- ability to “auto-fill” real weather data from selected weather stations (minimizing need to enter the data manually,
- automated updates of weather information as the season progresses, and automated update of the recommended irrigation schedule,
- yield score indicator, so they can consider alternative irrigation management strategies,
- the fact that the tool is based upon local research (conditions that are similar to their farms).

Improvements farmers and county agents identified:

- that the tool include additional THP crops (sorghum and corn were mentioned most),
- that the tool be adapted for mobile use (update critical inputs and receive outputs from the field via mobile apps for phone and/or tablets),
- that the tool keep other management records (fertilizer and other agrichemical applications, field observations, etc. as some producers keep hand-written notes or separate spreadsheet notes now),
- that the tool be “smart”, with capabilities to auto-calibrate for their operations (adapt predicted “yield score” to match yields of their fields),
- that the tool to be able to include near real-time data from field-based sensors with option to override soil moisture simulation.

Technical lessons learned include:

- the computational model needs to build upon a decomposable architecture; this makes it easier to extend components of the model (i.e., from a constant or simple formula to a more complex formula), it allows for varying resolution, and allows accepting as inputs other values computed elsewhere in the model at any time step,
- simple organization of the user interface; we constantly strove to make it simpler for casual users to use the tool and we decided to drop more complex views of data to reduce data overload and display a single comprehensive chart with a single simplified parameters view,
- calendar displays provide a simple and powerful means to display/summarize irrigation and rainfall data for editing and browsing,
- iterative development with periodic formal reviews and testing by subject-matter experts is important as it helps to ensure the developed tool appropriately meets end user needs and is both usable and useful.

The impact of this project will ultimately be in the future. The potential value of this effort can be quantified in that one inch of water conserved on half the irrigated cotton acreage in the THP is greater than the current Lubbock municipal water demand for a 20-month period (83,000 ac-ft).
DIEM research team strongly believes this effort creates a timely method to get site-specific, science-based irrigation information in the hands of producers in a relatively “painless” format.

Additional Information:

Intellectual Property:

The approach taken in this project is extensible and will be used to consolidate multiple methods of providing irrigation decisions. It is scalable to include multiple crops with recommendations based on current and predicted future conditions (weather and commodity prices). This point highlights the strong potential for the production and eventual transition of intellectual property including licensing potential for software products and the knowledge base developed in recent and ongoing field research.

A software disclosure entitled “Dashboard for Irrigation Efficiency Management (DIEM)” and a trademark proposal questionnaire and the necessary documentation related to DIEM software were submitted to Texas A&M System Technology Commercialization Office (TTC). Following consultations with TTC and Texas A&M AgriLife Research Corporate Relations (CR), a draft executive summary and a one-page description of the DIEM project was prepared for use by CR for exploring commercial opportunities. (Please see this document, attached.)

At the appropriate time, potential industry partners will be approached to provide development resources in return for rights to use DIEM to leverage their products.

Source and Amount of Funds Leveraged:

The following proposals related to project activities have been submitted:

- Requested/Not Funded:
  - NIFA AFRI Water for Agriculture Challenge grant was submitted on 13 Aug. 2014. Advancing Irrigation Scheduling for the 21st Century. With Kansas State University and USDA-ARS. Request $5,000,000 ($1,316,457 to Texas A&M AgriLife Research).

- Outstanding Requests
  - NIFA AFRI Water for Agriculture Challenge 4-year grant was submitted July 2015. Sustaining agriculture through adaptive management to preserve the Ogallala Aquifer under a changing climate. With Colorado State University, University of Nebraska, Kansas State University, Oklahoma State University, West Texas A&M University, Texas Tech University, New Mexico State University, USDA-ARS. Request $5,000,000 (AgriLife Research portion supporting DIEM related activities, $103,916).

- Funded Requests
sorghum production in the Texas High Plains under current and future climate scenarios. Total funded - Texas A&M AgriLife, $44,220.

Publications/Presentations Generated:
To date, there have been “by invitation only” DIEM presentations for protection of intellectual property. Field research and cotton crop modeling that support DIEM development are reported in the following future publications:

Dashboard for Irrigation Efficiency Management

Problem
The continuous decline in well capacities in the central US will result in “limited irrigation” being practiced on a majority of irrigated cropland. For example, cotton production is hampered on two million acres in the Texas High Plains (THP) by falling irrigation capacities, irregular rain events, and newly imposed irrigation pumping volume limits.

New Strategies
Recent THP cotton research has provided alternative management strategies that reduce irrigation without substantial yield loss when faced with limited and irregular availability of water. DIEM captures these and other research results in a single integrated, web-based software solution for forecasting field-specific irrigation schedules that optimize rainfall and irrigation use efficiency. This is accomplished by configuring basic historic, near real-time, and future agronomic information including weather, soil and crop characteristics, and irrigation parameters into an array of interactive data visualizations for portraying key aspects that support irrigation decisions.

Screenshot of DIEM's interface
Why DIEM?

DIEM uses a daily soil water balance method to estimate soil water content and water needs of a crop similar to other irrigation scheduling tools. However, DIEM evaluates season long water availability in specific fields and develops irrigation schedules for the remaining growing season subject to known and probable future water conditions. Those irrigation projections are evaluated with DIEM’s “score card” outputs. DIEM provides an irrigator the ability to visualize relationships among soil water, plants, and weather, and, if desired, evaluate risk using “what-if” evaluations at any time before or during the growing season using continually updated data.

Current Status

A proof-of-concept system for cotton has been developed and deployed, and it is undergoing preliminary pilot testing. As DIEM evolves, it will continue to be tested and evaluated by AgriLife Extension personnel and THP producers in order to determine its usefulness, accuracy, and robustness. DIEM creates a foundational basis for supporting a broader array of irrigation decisions, including management of multiple crops and in-season crop water reallocation among crops. It also provides a foundation for integrating different data sources (soil, plant, and/or other field-based or remote (UAV) based sensors) along with different visualization and analytical tools operating on the raw and computed result data.