Final Report

THE UNIVERSITY OF ARIZONA
Yuma Center of Excellence for Desert Agriculture

Arizona Iceberg Lettuce Research Council

Project Title & agreement number	Development of an Iceberg Lettuce Irrigation/Salinity Management App (AILRC 21-06)
Project Timeline	September 1, 2020 – February 28, 2022
Principal Investigator	Paul Brierley Yuma Center of Excellence for Desert Agriculture (YCEDA) University of Arizona
Co-Investigator(s)	Dr. Charles Sanchez Department of Environmental Science University of Arizona
Cooperating Investigator(s)	Dr. Andrew French Arid Lands Agricultural Research Center USDA-ARS

Executive Summary

With previous funding from the AILRC we collected background data to estimate evapotranspiration (ET) for lettuce from weather data and satellite imagery. We also collected data on irrigation management and its impact on soil salt management. The objective of this project was to utilize these data to develop an irrigation and salinity management APP. UArizona's Yuma Center of Excellence for Desert Agriculture (YCEDA) and USDA-ARS's Arid Lands Agricultural Research Center (ALARC) worked closely with the UArizona Communications & Cyber Technologies (CCT) team in building the computational algorithms and user interface. The APP allows for the selection of fields to grow a crop, the identification of soil types, tracking of irrigation and rainfall, and helps forecast suggested time and depth of future irrigations using recently compiled and historical weather data. This work represents an extension of the previously-developed DesertAgWISE APP for cotton and Durum wheat to lettuce. A feature of DesertAgWISE that distinguishes it from other irrigation advisory tools is that it tracks salt balance over time and provides estimates of water required for leaching of excess salts. The APP is currently undergoing internal and selected user (stakeholder) testing and we anticipate field testing this coming growing season.

Background

Lettuce production in Yuma is a multi-million-dollar industry relying entirely on irrigation water from the Colorado River. However, competition for water between nations, states, agricultural, industrial, urban and environmental interests is already commonplace, and all users are being challenged to use water more efficiently. The total amount of water required by iceberg lettuce includes that used by the crop for evapotranspiration (ET) and an additional amount to leach excess salts from the root zone, known as the leaching requirement (LR). Lettuce is a salt sensitive crop and irrigation with Colorado River water diverted at Imperial Dam requires a LR of 20% ET to sustain production.

Paramount to efficient irrigation management are accurate estimates of crop ET and the tools to use these estimates. Irrigation time is determined by the allowable depletion of available water within the soil profile to avoid yield loss, and the required depth is determined by the amount required to refill the water lost from the soil profile by ET.

The depletion of soil moisture by crops can be measured directly by soil sensing devices or estimated from weather-based ET measurements. Where crop ET (ETc) is calculated from Eto and crop coefficients (kc), and Eto is calculated using weather-based equations (e.g., Penman Monteith or others). Work was needed to develop crop coefficients for lettuce.

Over the past decade, there have been significant advances in technologies to measure crop ET under field conditions. One such technology is Eddy Covariance (ECV). Eddies are turbulent airflow caused by wind, the roughness of the Earth's surface, and convective heat flow at the boundary between this surface and the atmosphere. Etc occurs when water vapor in upward moving eddies is greater than in downward moving eddies. Sensible heat is positive when upward moving eddies are warmer than downward moving eddies. Water vapor, heat, and carbon dioxide transferred by eddies can be measured directly using ECV.

While the Eddy Covariance (ECV) methods we used are highly accurate and reliable and have given us consistent results, equipment purchase, operation, and maintenance are expensive and not a practical management tool that the industry can use directly. However, we have developed a very reliable methodology to ground truth and calibrate more user-friendly data collection methodologies, including satellite imaging data. There have been recent developments in the use of satellite imagery to estimate Etc. A previous limitation for produce crops was the infrequent flyovers relative to crop growth rates, and low resolution of imagery. More recently, we have gained access to higher resolution data collected at minimum of weekly flyover times – often every two days. During 2018-2019, we evaluated the utility of space-based sensors and compared estimates to our ground-based measurements.

As part of a large, multi-year Yuma-area irrigation and soil salinity management project coordinated by the Yuma Center of Excellence for Desert Agriculture (YCEDA) and led by Dr. Charles Sanchez at the University of Arizona and Dr. Andrew French at the USDA-ARS Arid Lands Ag Research Center, we have built a unique database of updated crop water use (Etc) and soil salinity impacts for iceberg lettuce and its typical desert rotation crops of melons, wheat, cotton and Sudan grass. We have shown that in most cases, irrigation efficiencies in the iceberg lettuce cropping systems are very high (85-90% or more) and therefore do not provide the needed 20% leaching requirement – leading to salt buildup in the soil.

In 2020 we began working with the Communications & Cyber Technologies (CCT) team in the University of Arizona's College of Agriculture and Life Sciences to develop an irrigation/salinity management mobile APP titled DesertAgWISE, where the letters of WISE stand for **W**ater **I**rrigation **S**oil **E**nvironment. The APP seeks to track crop water use and soil salinity balance, and allow farmers to utilize real-time satellite and weather data when making irrigation decisions based on the ETc and soil salinity needs as found in our unique database, in order to maximize irrigation water-use efficiency while providing adequate water to the crop and sufficient leaching of soil salinity to allow for sustained production. Based on funding, the first App modules developed focused on cotton and wheat. The objective of this proposal was to extend the DesertAgWISE mobile App to iceberg lettuce using the database obtained with previous AILRC funding.

During 2018-2019 under an AILRC project titled "Evapotranspiration from Desert Iceberg Lettuce Production Systems" we began compiling ETc estimates for lettuce using ECV methods. During 2019-2020 under an AILRC project titled "Satellite Measurement of Evapotranspiration (ET) from Desert Iceberg Lettuce Production Systems**"** we enhanced our database using ECV methodology and evaluated satellite base sensor technologies as tools for ETc estimation. During 2020-2021, our objective was to develop algorithms for a component of the DesertAgWISE mobile APP irrigation management tool for lettuce growers based on ET and soil salinity needs.

Database

The database utilized in the development of the DesertAgWISE mobile APP was compiled with previous AILRC funding from 2017-2020. These data were collected in lettuce production fields of grower cooperators in Yuma County, Arizona. Results have been summarized in previous reports to AILRC and we are currently wrapping up the publication in scientific journal articles. Briefly, crop evapotranspiration (ETc) was measured in fields using eddy covariance methodologies. Weather data from nearby AZMET stations were collected and Penman-Monteith ETo values compiled. Satellite imagery was compiled and processed for NDVI, and ground-truthed utilizing drones, as a potential aid in irrigation scheduling. Salinity was monitored by EM 38 conductance surveys augmented by soil sampling and laboratory analysis.

APP Development

The scientific team that collected all the background data (Drs. French, Hunsaker, and Sanchez), along with YCEDA personnel (Paul Brierley and Sonnet Nelson) had weekly meetings with CCT personnel to incorporate the appropriate scientific data into algorithms that allowed the development of a user-friendly management tool for growers and their personnel to make irrigation decisions. Growers were surveyed for input on the most important features and functions of the APP so that it will best fit their operations, and select growers and researchers will field test the App before its full release to the Arizona lettuce production industry. Future grant funding will add additional capabilities and integration with other management systems.

DesertAgWISE Mobile APP Features

Some features of the DesertAgWISE mobile APP are illustrated in screen shots (Figures 1 through 8).

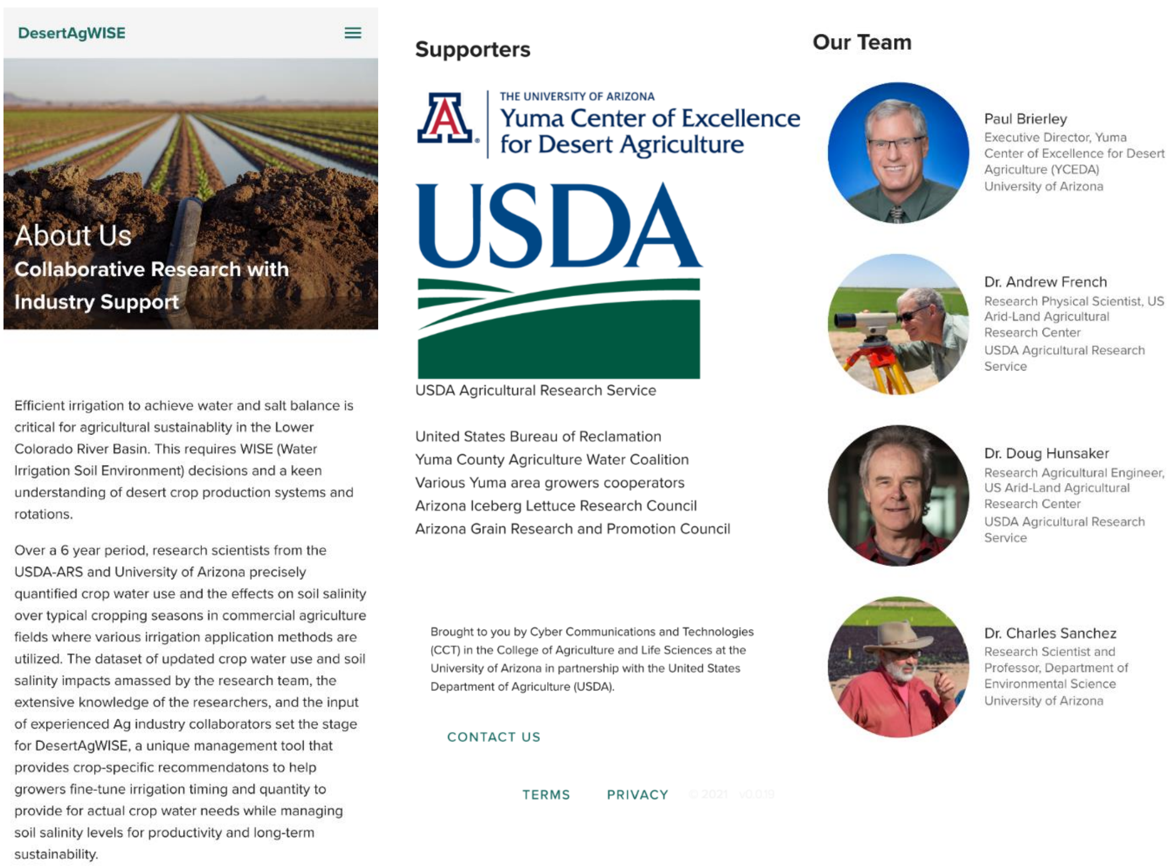

Figure 1. Introductory pages to the DesertAgWISE mobile APP with recognition of team and industry partners.

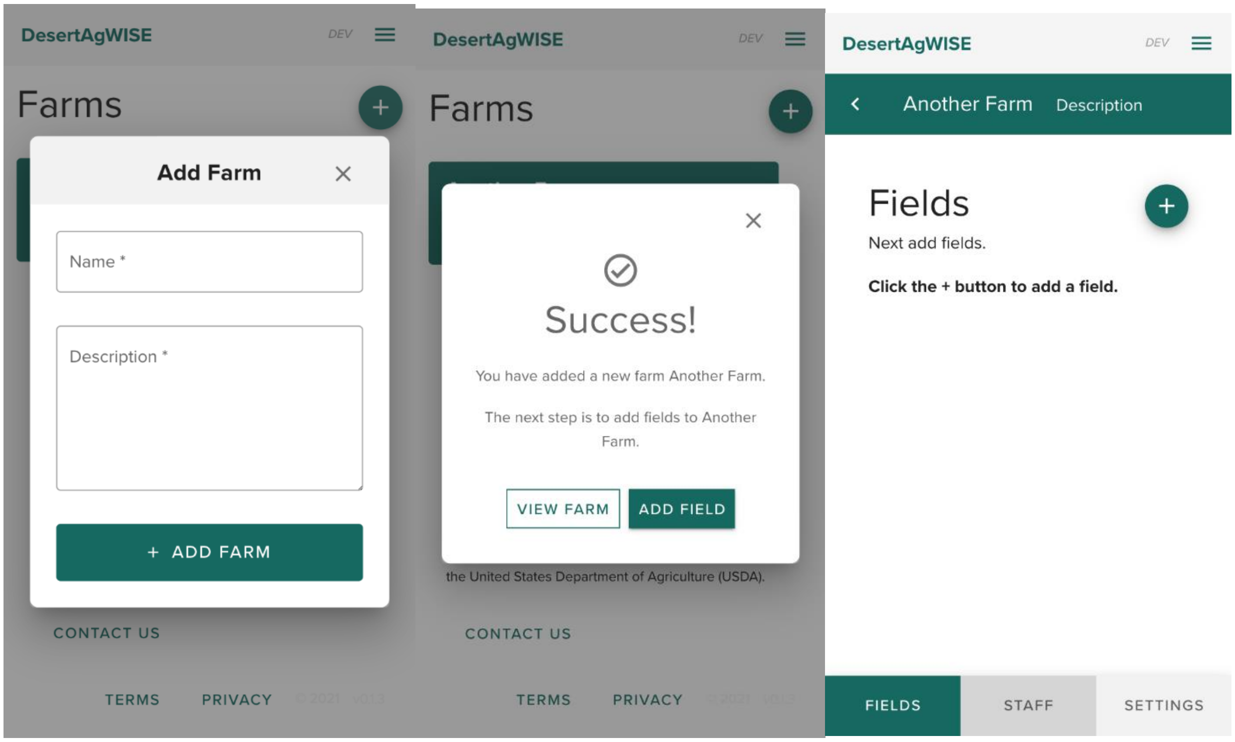

Figure 2. Farm input pages used to create a farm in the DesertAgWISE mobile APP.

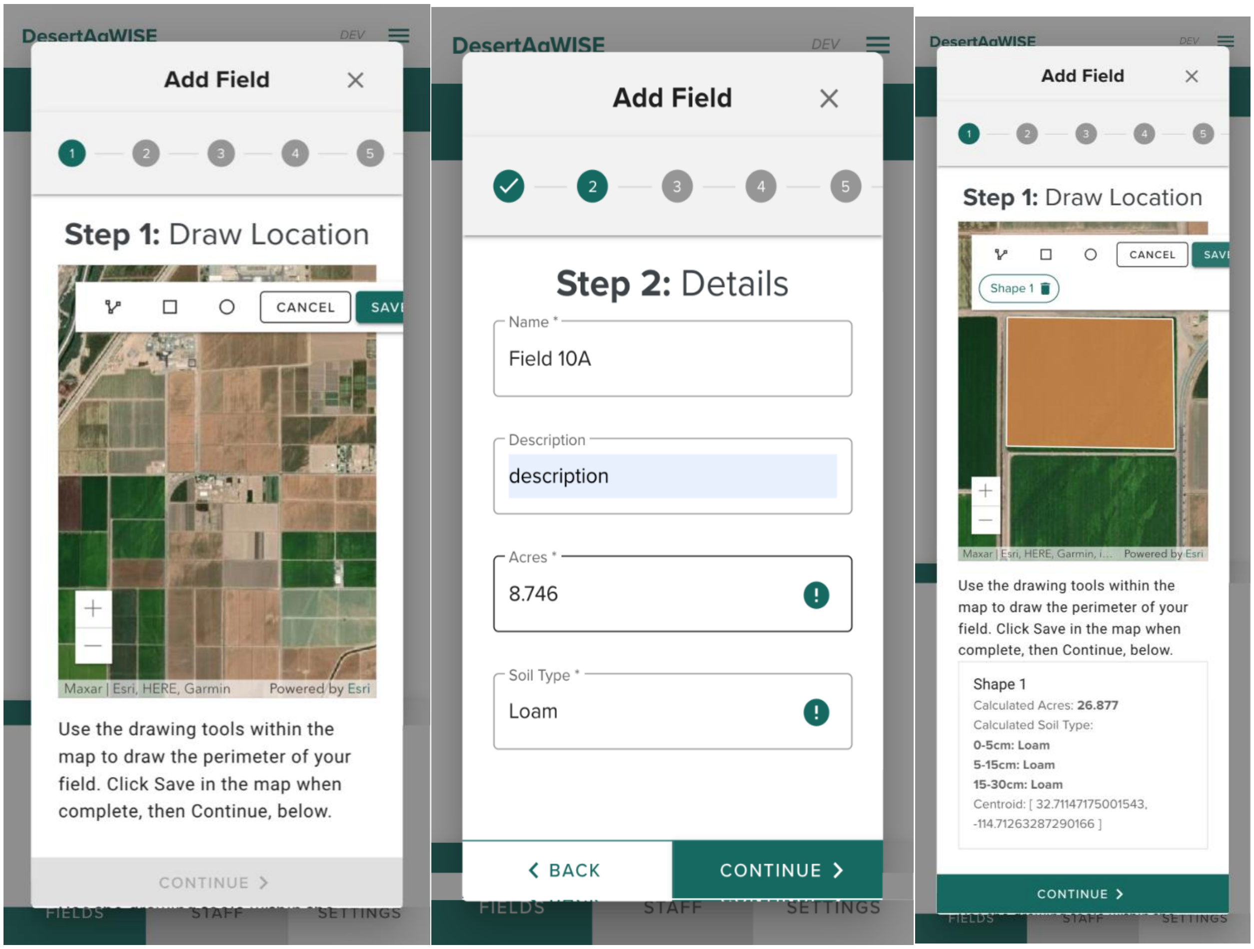

Figure 3. Field creation and definition pages. The DesertAgWISE mobile APP automatically utilizes the definition of soil type from a publicly-available database for the field location. However, manual override is allowed if grower has more-specific soil type information.

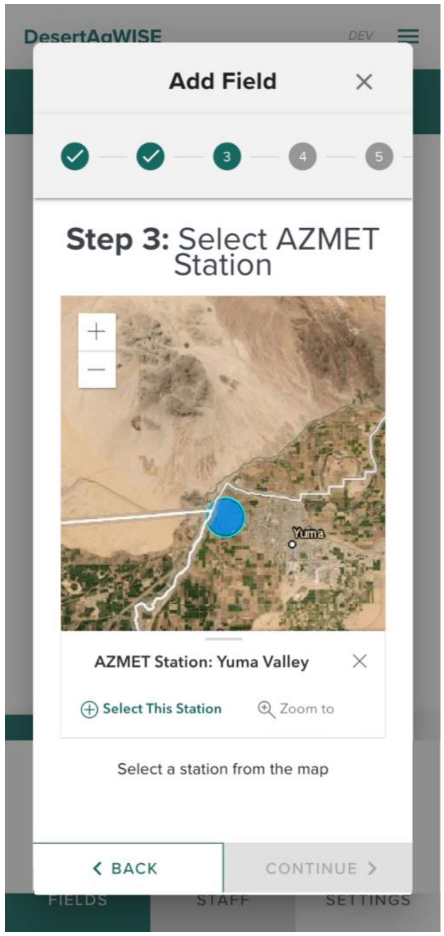

Figure 4. App defaults to the nearest AZMET weather station but also allows for manual override to use a more-appropriate AZMET station. The possibility of using other, non-AZMET, weather stations is coded into the DesertAgWISE mobile APP.

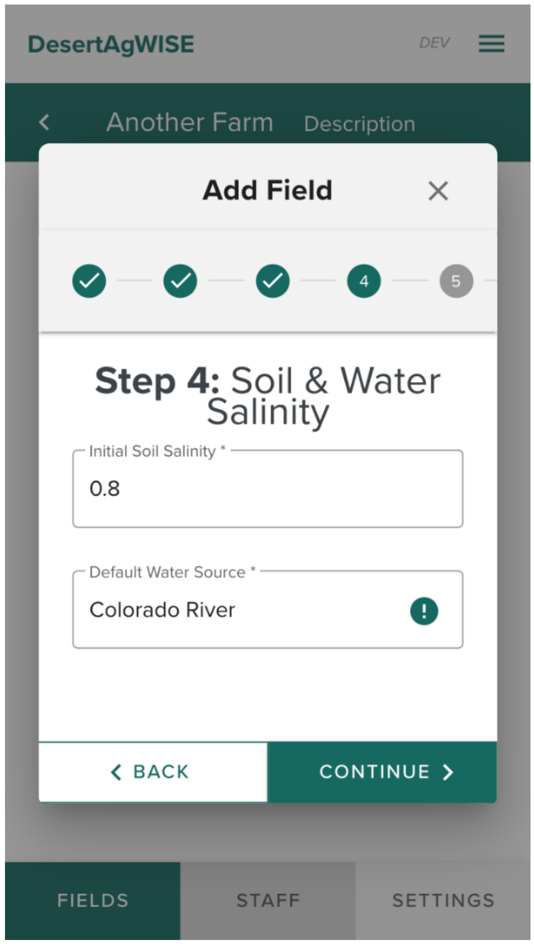

Figure 5. The DesertAgWISE mobile APP defaults to Colorado River water salinity characteristics, but allows for salinity inputs to be customized for a different water source.

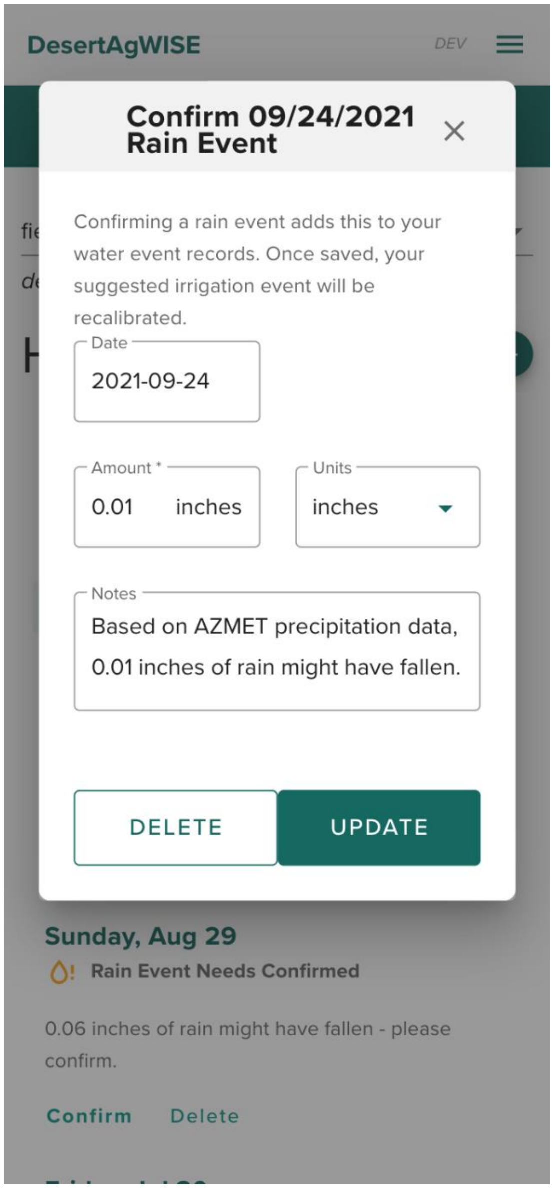

Figure 6. The DesertAgWISE mobile APP compiles rainfall data from the selected AZMET station but also allows manual override should grower have better site-specific information.

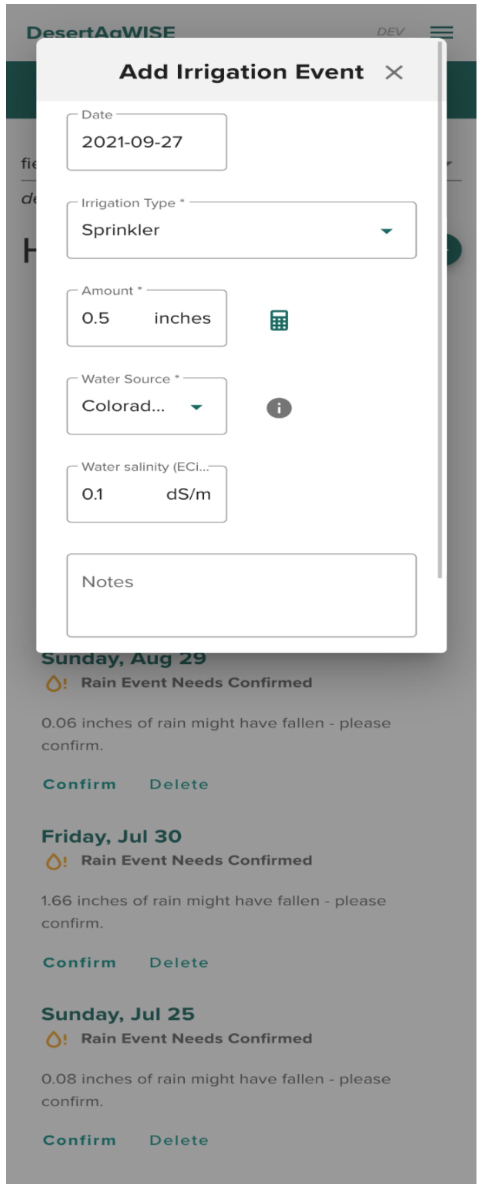

Figure 7. Characteristics of irrigation events are entered into the DesertAgWISE mobile APP.

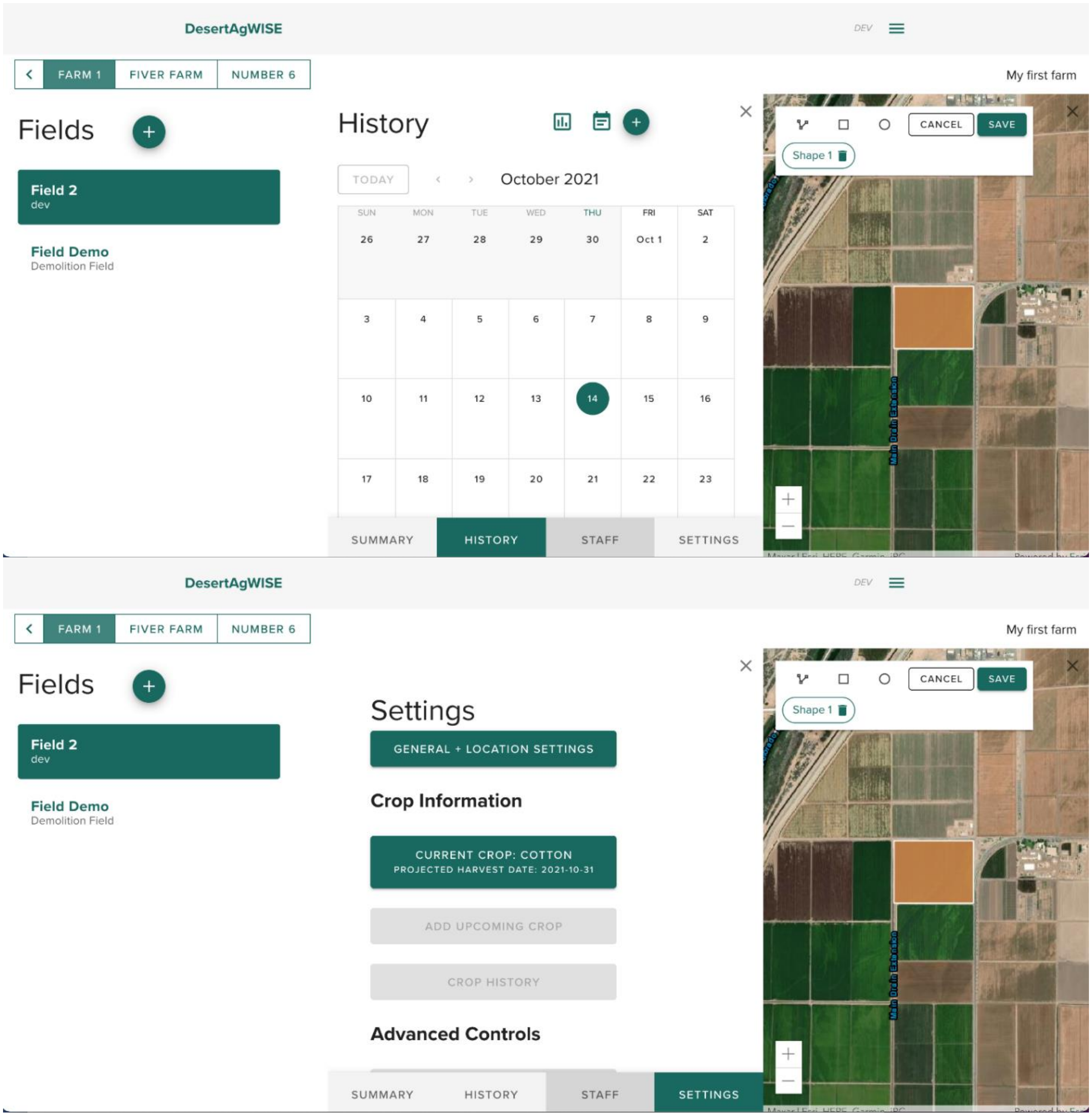

Figure 8. Selected output pages of the DesertAgWISE mobile APP that provide field-specific recommendations and information to growers.