Final Report

THE UNIVERSITY OF ARIZONA
Yuma Center of Excellence for Desert Agriculture

Arizona Grain Research and Promotion Council

Project Title & agreement number	Development of an APP for Durum Wheat Water Management (20-01)
Project Timeline	January 1, 2020 – June 30, 2021
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 U.S. Arid Lands Agricultural Research Center USDA-ARS

Executive Summary

With previous funding from the AGRPC we collected background data to estimate evapotranspiration (ET) for Durum wheat 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. The UA Yuma Center of Excellence for Desert Agriculture (YCEDA) and USDA Arid Lands Agricultural Research Center (ALARC) worked closely with the University of Arizona College of Agriculture & Life Sciences Communications and Cyber Technologies (CCT) team in building the computational algorithms and user interface. The APP allows for the selection of fields, the identification of soil types, tracking irrigation and rainfall and helps forecast optimal time and amount of future irrigations using recently compiled and historical weather data. A feature of this APP that distinguishes it from other irrigation advisory tools is that it tracks soil salt balance over multiple seasons and provides estimates of water required for leaching of excess salts. We anticipate field testing of the APP this coming growing season.

Background

Durum wheat produced in the desert is established (germinated) by either planting into soil moisture (shortly after a pre-irrigation), sprinkler irrigation after seeding, or by basin surface irrigation after seeding. After stand establishment, all wheat is irrigated by basin surface irrigation. Paramount to efficient irrigation management is accurate estimation 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 ETc is calculated from ETo and crop coefficients (kc), and ETo is calculated using weather-based equations (e.g., Penman Monteith or others). Updated crop coefficients for desert wheat with planting dates from November through early March were developed in earlier AGRPC-funded research projects.

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. ET 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.

The ECV method is now a well-established, standardized, and state-of-the-art approach for measuring ET and results from ECV stations are considered reference quality. Nevertheless, ECV data have some shortcomings. ET values are locally, but not regionally, representative of environmental water fluxes. Second, ET values have a variable geographic footprint, which is dependent upon uncontrollable wind speed, wind direction effects. These shortcomings mean that ET assessments over multiple farms and heterogeneous landscapers are difficult and potentially biased.

An alternative approach that is better suited for larger scale ET studies is Large Aperture Scintillometry (LAS), a technique that allows ET measurements to be scaled up over space and time. Thus, field estimates should be less susceptible to local bias and varying flux footprint, which in turn means that estimates from diverse cropping systems can be measured concurrently over scales approaching 5 kilometers.

There have been recent developments in the use of satellite imagery to estimate ET. 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. We are currently using data from Landsat 8 (https://www.nasa.gov/mission_pages/landsat/launch/index.html) Sentinel 2a/2b (https://www.esa.int/Our_Activities/Observing_the_Earth/Copernicus/Sentinel-2) and VENuS (https://venus.cnes.fr/en/VENUS/GP_mission.htm) satellites. ECOSTRESS was launched June 29, 2018 (https://ecostress.jpl.nasa.gov/events/ecostress-launch) and we now have data for the Yuma and Maricopa areas.

During 2016-2017 under an AGRPC project titled "Water and Salt Balance for Durum Wheat Irrigation", we began compiling ET estimates for Durum wheat. During 2017-2019 under an

AGRPC project titled "Measuring Evapotranspiration of Desert Durum at Multiple", we enhanced our database using ECV methodology and evaluated ET at multiple scales using is Large Aperture Scintillometry (LAS) and satellite base sensor technologies. During 2019-2020, our objective was to develop algorithms for a component of a mobile APP management tool that would allow Durum wheat growers to utilize this satellite data when making irrigation decisions based on ET and soil salinity needs.

Database

The database utilized in the development of the APP was compiled with previous AGRPC funding from 2016-2019. These data were collected in Durum wheat production fields of grower cooperators in Yuma and Pinal Counties, Arizona. Results have been summarized in previous reports to AGRPC and published in a scientific journal article (French et al., 2020). 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 as a potential aid in irrigation scheduling. Soil 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) have been having weekly meetings with CCT personnel to incorporate the appropriate scientific data into algorithms that allow the development of a user-friendly management tool for growers and their personnel making irrigation decisions. The App will be beta tested in the field during the upcoming wheat growing season.

APP Features

Some features of the APP are illustrated in screen shots in Figures 1 through 8.

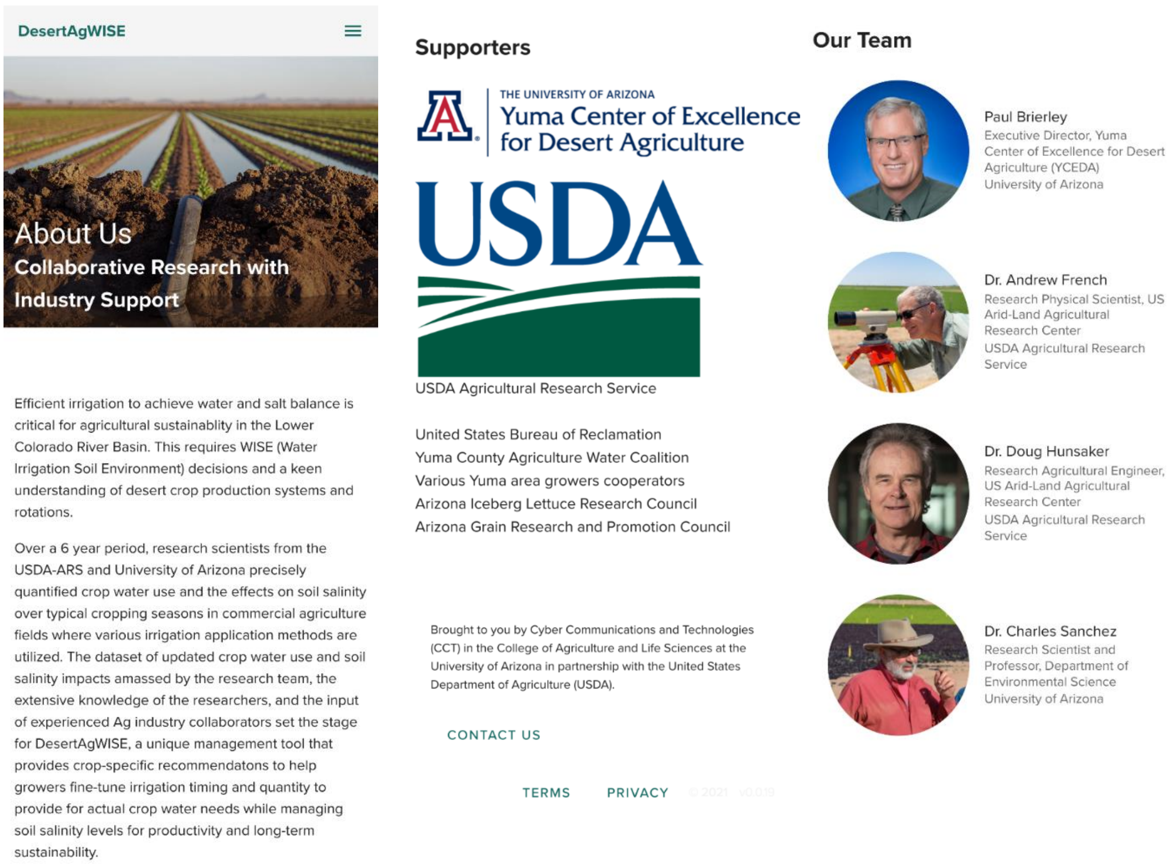

Figure 1. Introductory pages to APP with recognition of team and industry partners.

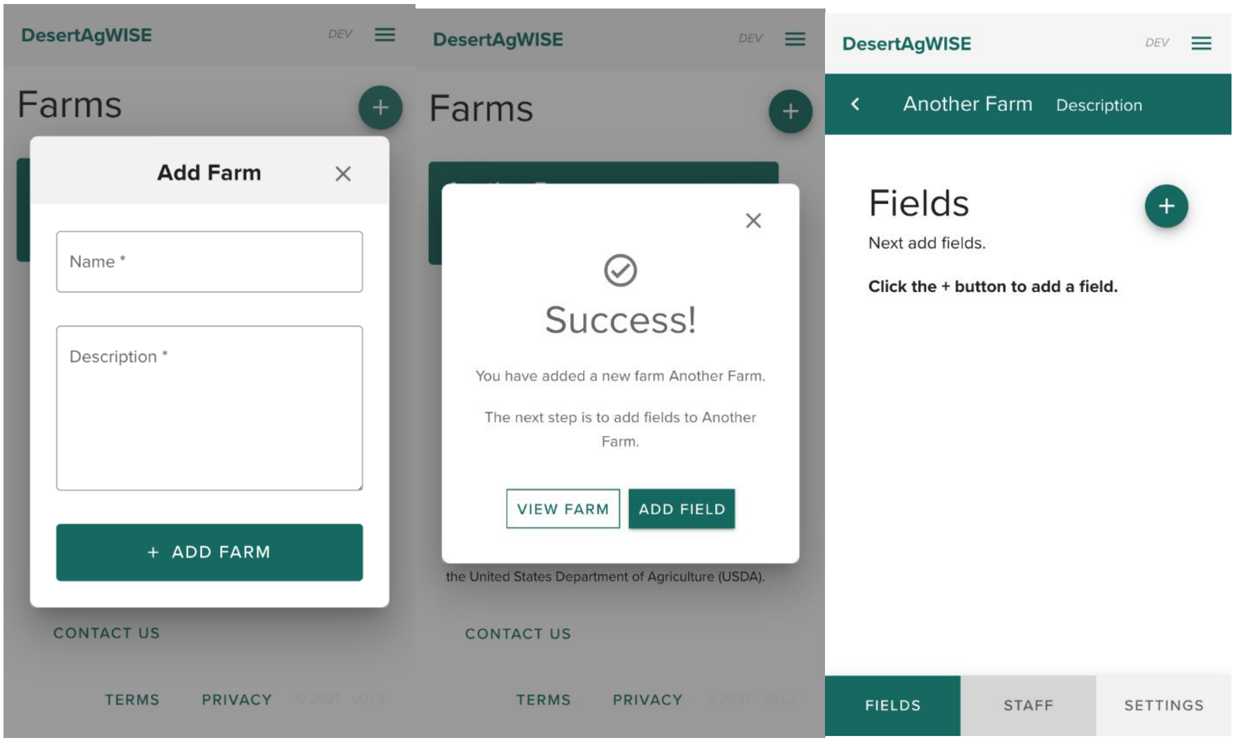

Figure 2. Farm input pages

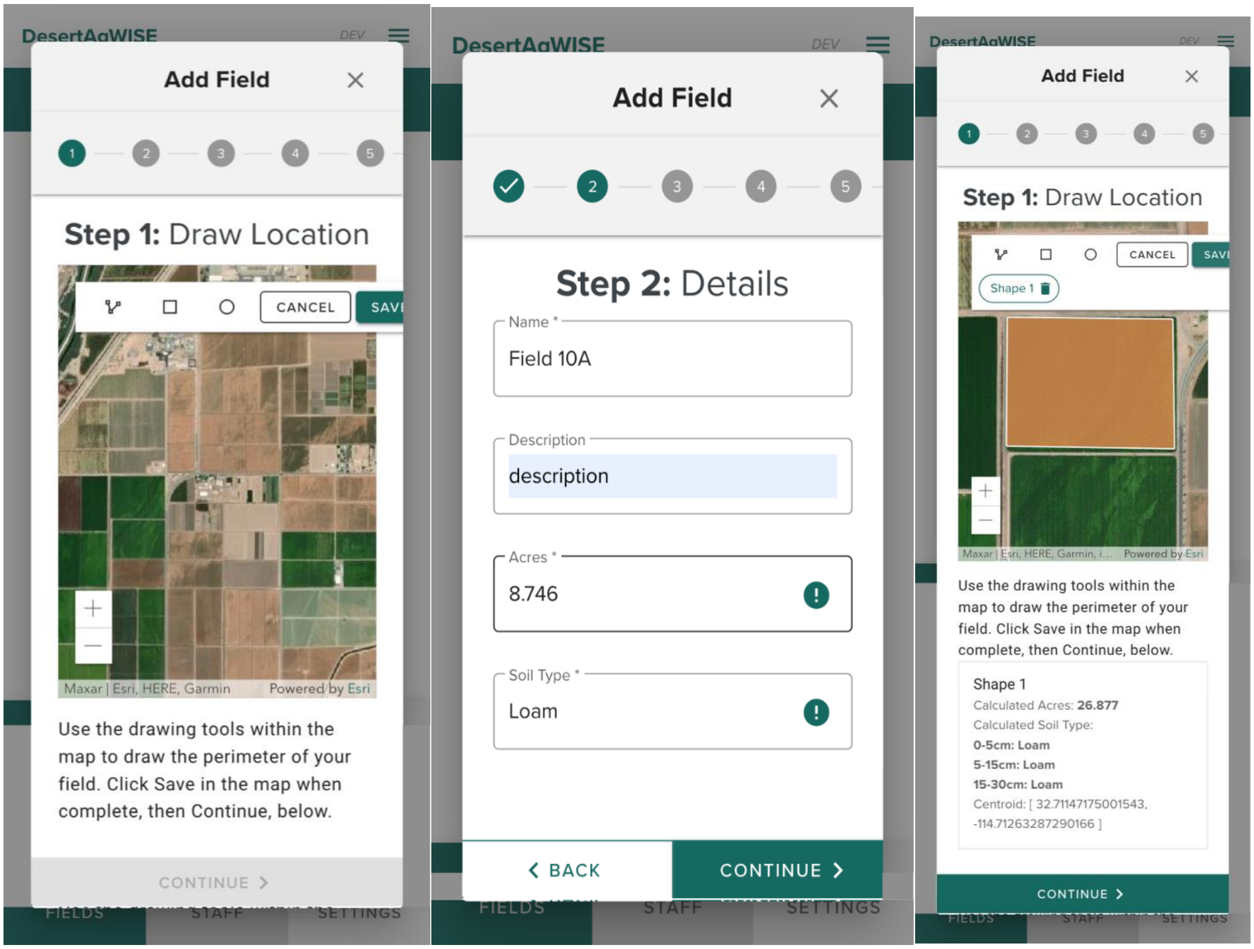

Figure 3. Field input and definition pages. The APP automatically facilitates definition of soil type from existing databases for specific field locations. However, manual override is allowed if grower has more accurate information.

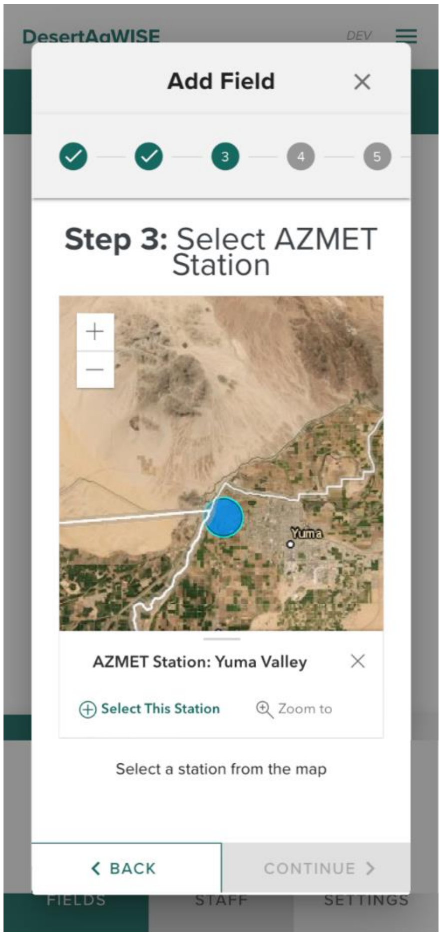

Figure 4. App will default to nearest AZMET weather station but also allows for manual override to a more appropriate station, for example if the nearest station is over a hill in a different microclimate.

Figure 5. The App allows for manual salinity inputs but defaults to historical Colorado River water salinity levels.

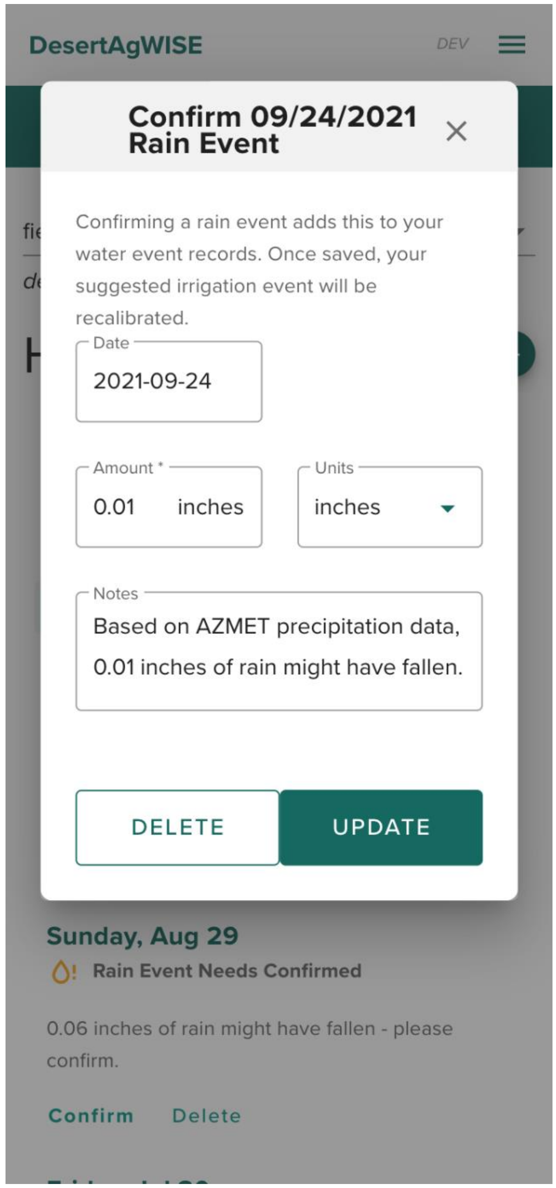

Figure 6. The App compiles rainfall data from the selected AZMET station but also allows manual override should grower have more accurate site-specific information.

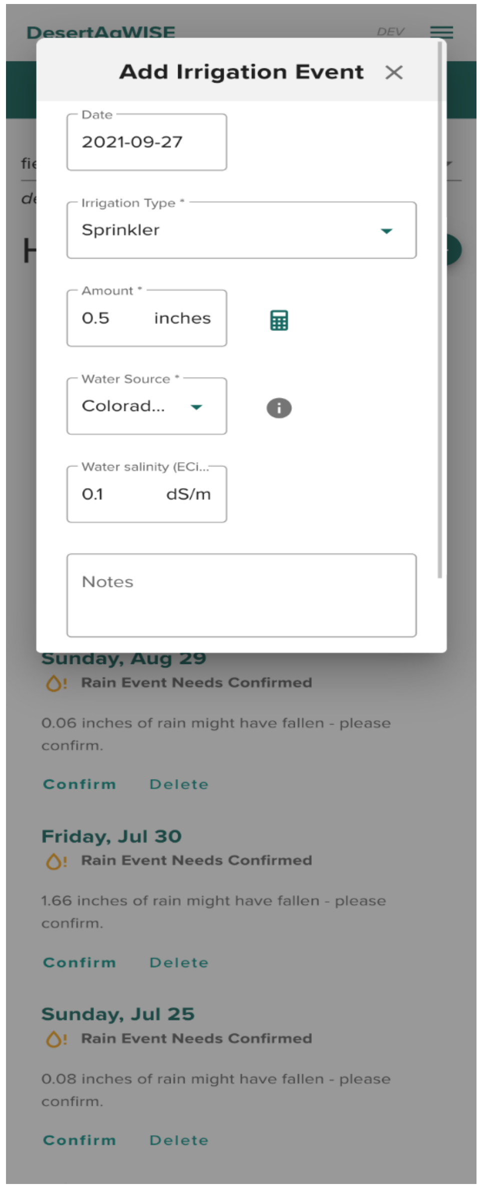

Figure 7. The App provides a page for recording irrigation events.

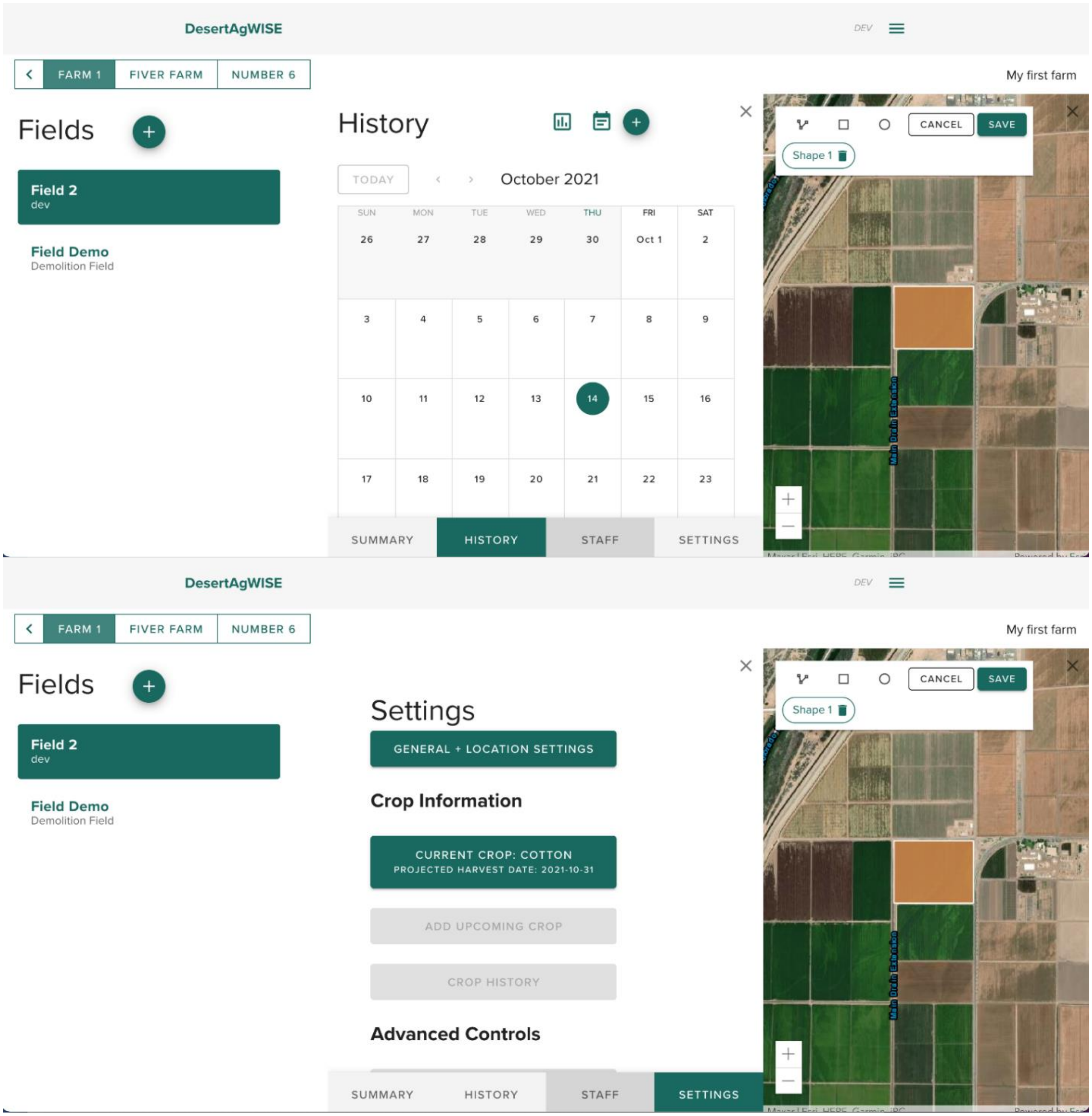

Figure 8. Selected output pages of the App provide the grower with information needed to best manage his crops.

Literature Cited

French, A. N., D. J. Hunsaker, C. A. Sanchez, M. Saber J. R. Gonzalez, and R. Anderson. 2020. Satellite-based NDVI crop coefficients and evapotranspiration with eddy covariance validation for multiple durum wheat fields in the US Southwest. Agriculture Water management. 239:https://doi.org/10.1016/j.agwat.2020.106266