Smartfield™ FIT System

Applications for Crop Monitoring and High-Throughput Phenotyping

HUNDREDS OF PLOTS › **MILLIONS OF DATA POINTS** › **TIMELY DATA ANALYSIS** › **FASTER PRODUCT ADVANCEMENT**

High Precision, High Resolution, and High Throughput

Smartfield™ FIT system allows for precise canopy temperature data capture throughout the season. Our system uses algorithms that integrates real-time environmental and actual physical measurements to produce millions of data points per season.

Smartfield believes in achieving a spatial-temporal balance between micro (e.g., field and plant level information) and macro (e.g., public weather information) databases to be able to make timely and meaningful binary decisions.

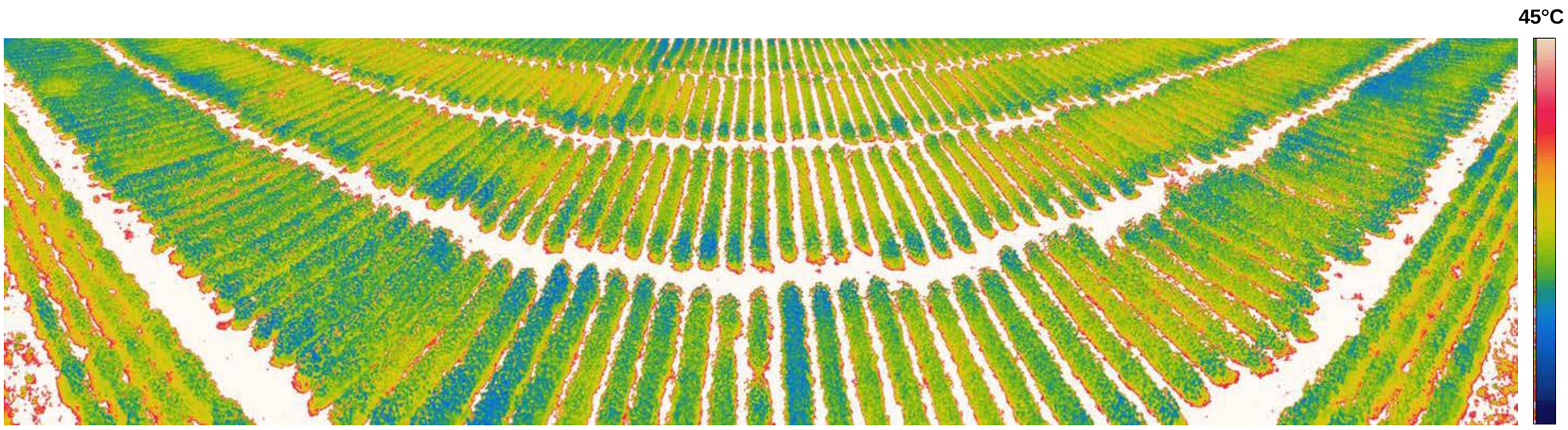
Key System Components

- Infrared and visual spectrum camera
- High performance pan-tilt system
- Custom hardware and software
- 50’ pneumatic mast
- Autonomous system

Key Features and Benefits

- Continuous measurement
- High temporal, spatial values
- Measures actual plant response
- Wireless, autonomous connectivity
- Non-invasive infrastructure

“Smartfield has developed proprietary algorithms and patented processes which convert continuous plant canopy temperature into Smartfield Stress Units (“SSU”). SSUs turn “Big Data” into actionable data delivered on a single daily message notifying the end user on the condition of their crop.” Steve M. Hawkins, CEO



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Smartfield™ FIT System

Helping Researchers Assess & Evaluate Cultivars & Crop Inputs

FEATURES	BENEFITS	ADVANTAGES
Continuous measurement	Complete picture Near real-time tracking of input impact	Cover thousands of plots with a single system Quantify genotype response to environment Quantify duration and impact of topical applications
Quantify plant performance efficiency	Actual plant response/ crop performance	Integrates all biotic and abiotic stress measurements Reduce time to market
High temporal, spatial values	High throughput, accurate early phenotyping	Improves biological significance
Valuable, actionable data	Binary solution/ binary decision capability	Segment entries by performance Recognize disease and pest impact before visual symptoms Early selection and forecast performance
Non-invasive infrastructure	Does not interfere with farm operations Easy to install	Confidence of direct measurement 24/7 Low maintenance
Wireless, autonomous connectivity	Monitor from anywhere in the world with connectivity	Data access on demand
RGB capable	Monitor fertility and biotic stress/complements infrared	Quantify input of topicals/interactions on plant
Commercial, high-grade equipment	Long service life	Valuable ROI Dependable management tool

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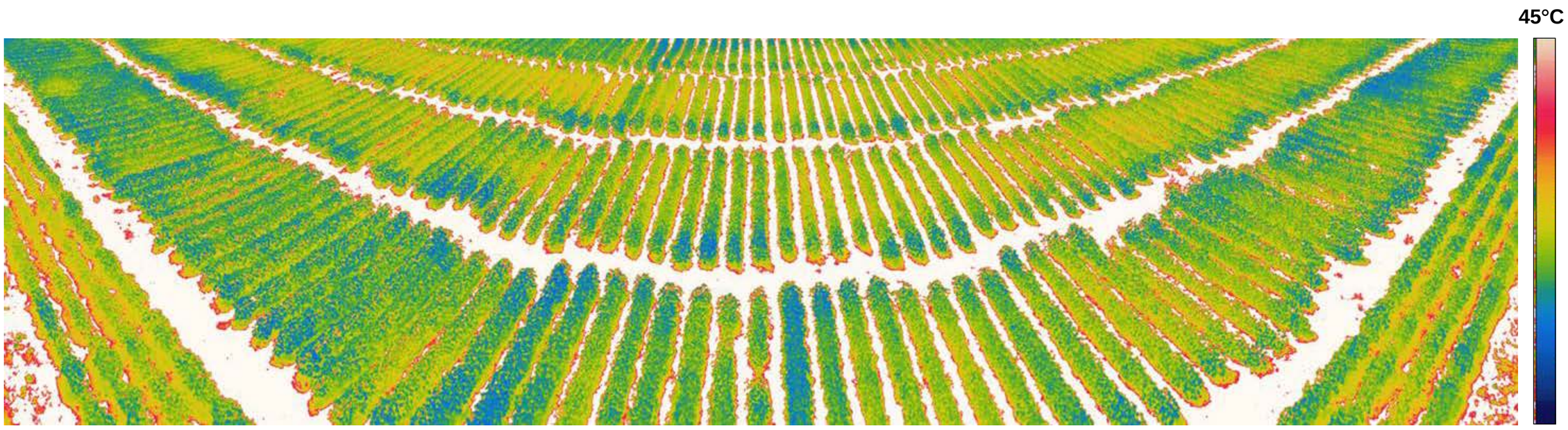

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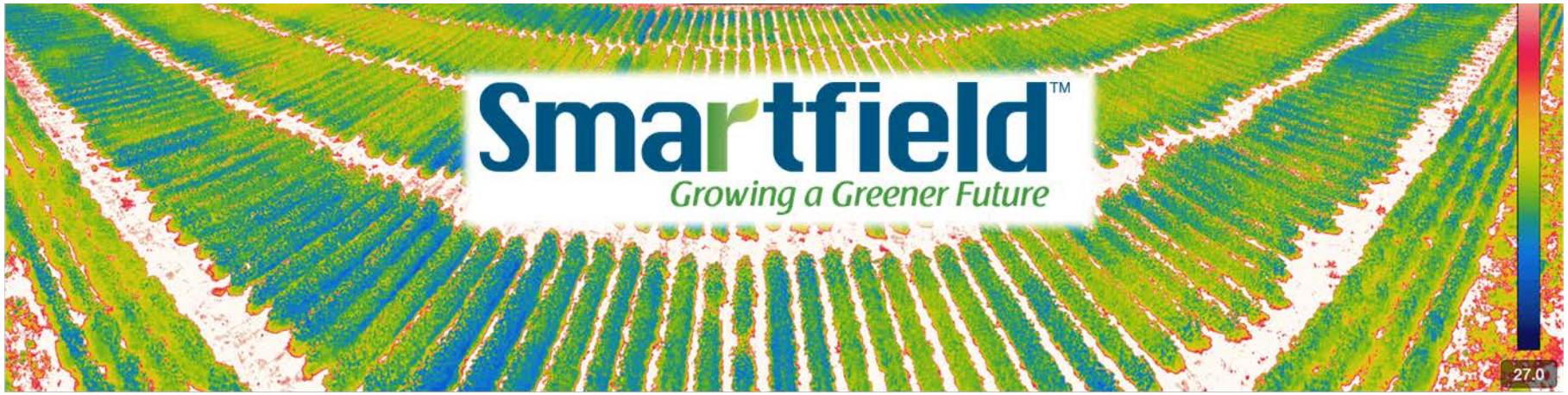

SMARTFIELD™ FIT SYSTEM

APPLICATIONS FOR CROP MONITORING AND HIGH-THROUGHPUT PHENOTYPING

The Plant is the Sensor™

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Smartfield: The Plant *is* the Sensor™

- Smartfield is an agricultural information company with proprietary developed technology and processes

- Smartfield was founded on an exclusive license from a USDA Patent (BIOTIC)
  - Biologically-Identified Optimal Temperature Interactive Console (BIOTIC) for managing irrigation

- Smartfield has added an additional patent around measuring plant canopy temperature (RACCC)
  - Remote Analysis and Correction of Crop Condition

- Smartfield's strategic goal is to capture continuous relevant crop data
  - To create timely analytical information
  - To make fact-based decisions in a timely manner
  - To result in financial success to our customers

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Smartfield: The Plant *is* the Sensor™

- Plant species have a leaf temperature at which they perform best – its called "Optimum Plant Canopy Temperature" (OPCT)
- Smartfield can identify OPCT for any crop
- Even different varieties, lines or hybrids of the same crop species can have different OPCT
- When a plant is under stress, it loses ability to regulate to its OPCT, thus losing yield

"The **more time a plant spends in a stressed state**, where it cannot correctly modulate canopy temperature, **the higher the magnitude of the yield loss**"

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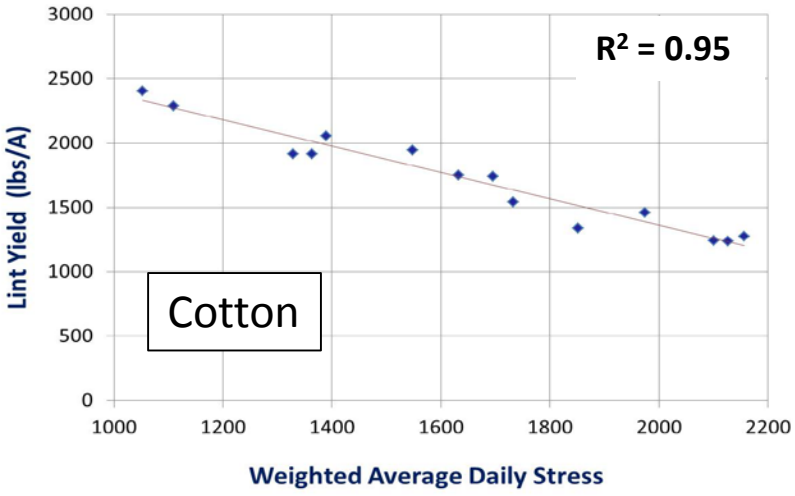
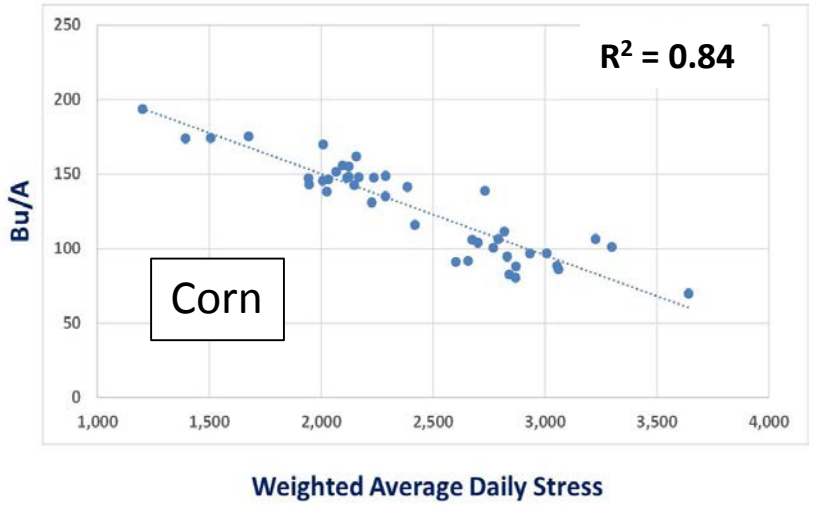
Canopy Temperature

- Canopy temperature is a direct, integrated measurement revealing plant health
  - Continuous canopy temperature measurement provides a complete picture of the season
  - Smartfield's algorithms creates a common stress unit (Smartfield Stress Unit = SSU)
  - Having a common stress unit makes recording of timing and duration of stress more objective rather than subjective (e.g., visual)





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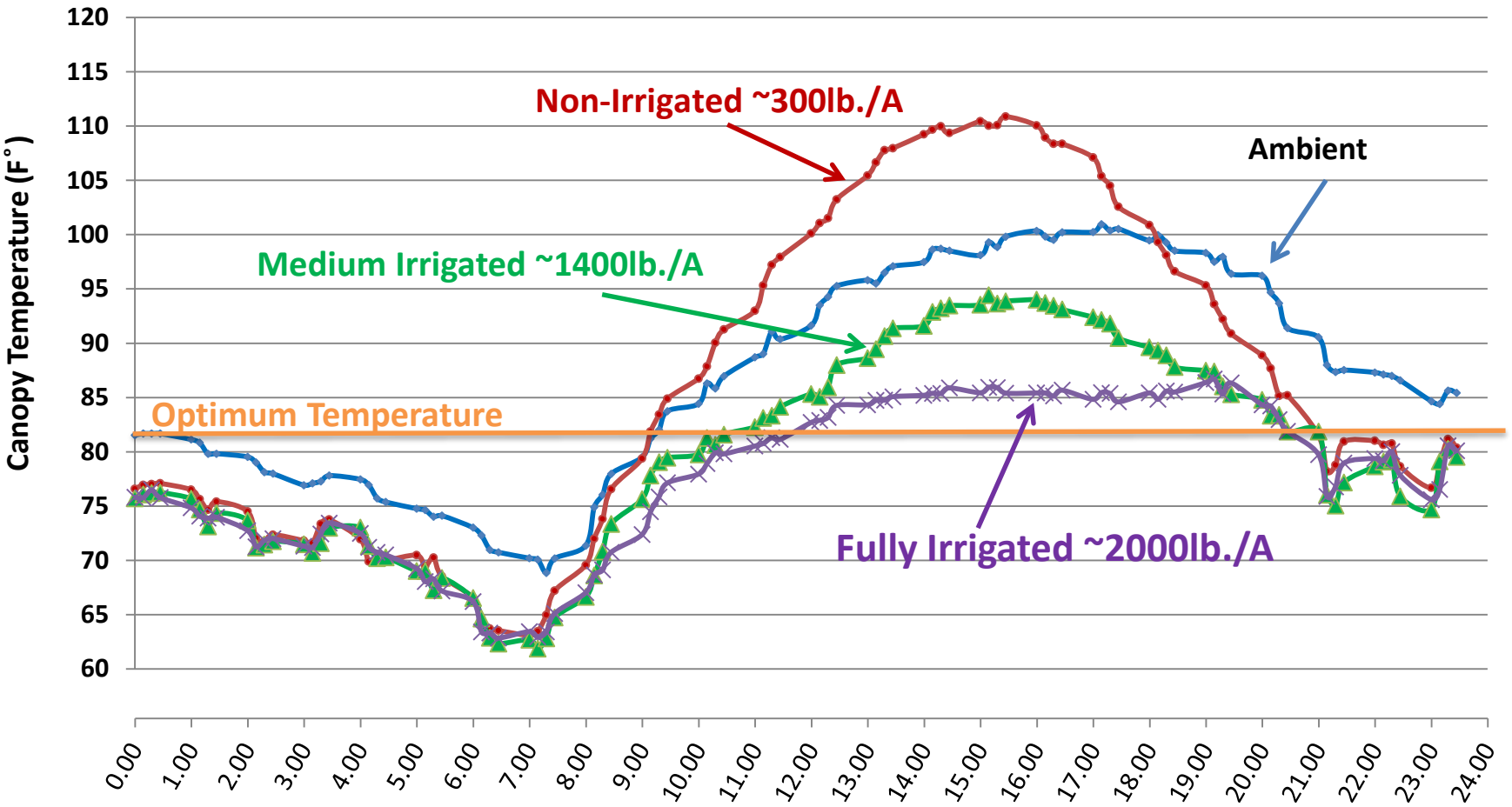
Continuous vs. Episodic Data Capture

96 data points per day provide a complete daily picture!



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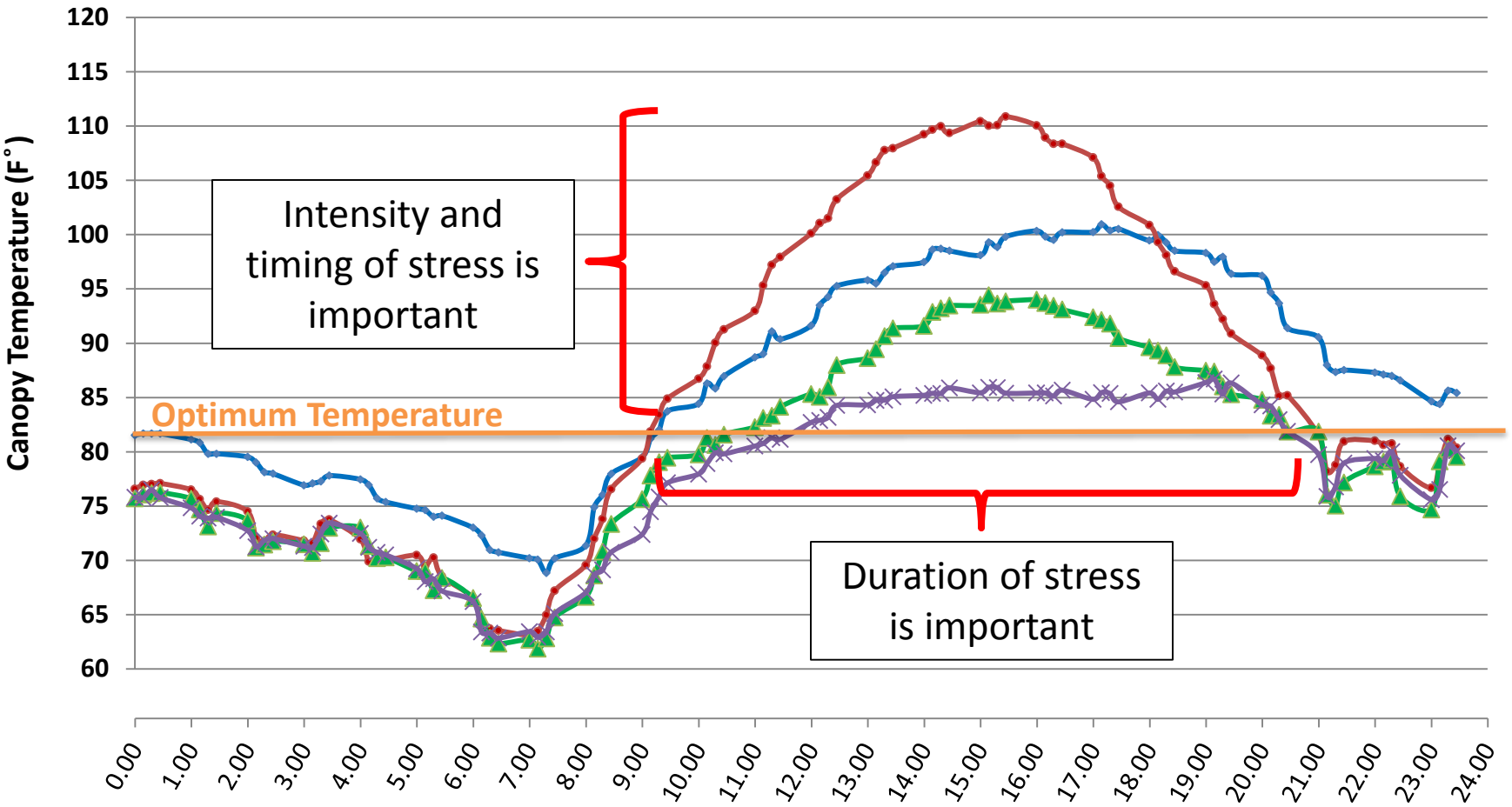

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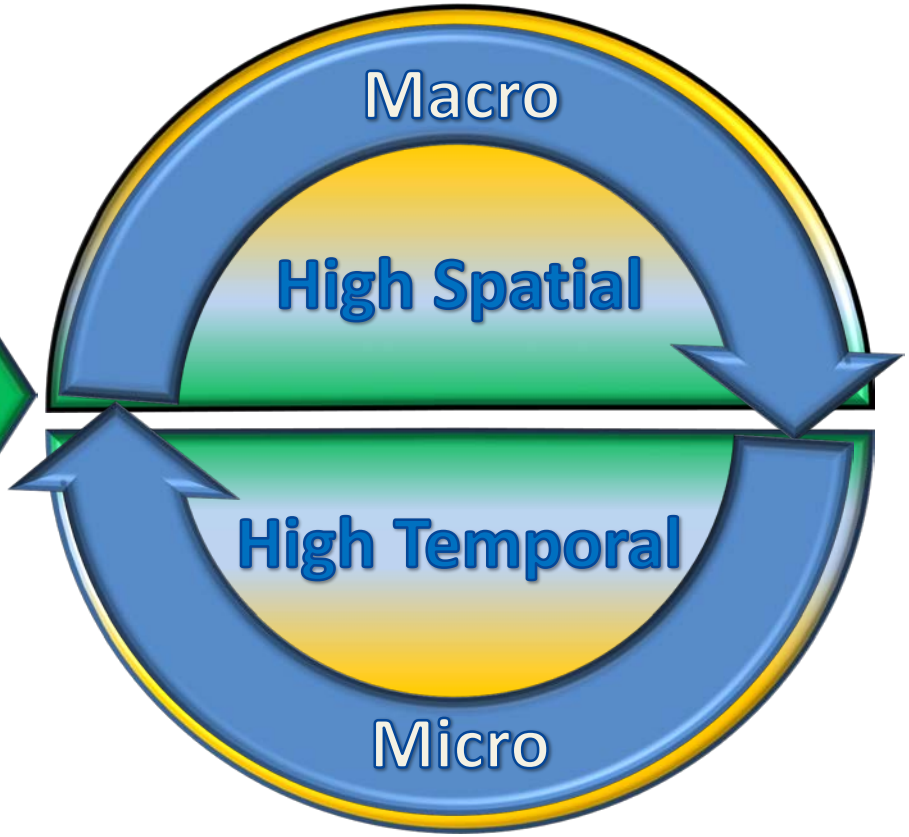
Approaches to Data Generation and Mining

Macro is the use of public databases parsed to the field level

Smartfield believes the long term solution will be a blend of both macro and micro databases to achieve a spatial –temporal balance

Micro is building the database and mining at the sub-field level to the field level



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Smartfield™ FIT System –Definition

Key System Components

- Infrared camera
  - 640x480 resolution
  - High-accuracy for relative analysis
- Visual spectrum camera
  - 1080p resolution
  - 30x optical zoom
- High performance pan-tilt system
  - Accurate & repeatable motion control platform
  - Slip rings allow for continuous 360° rotation
- Custom hardware
  - Algorithm refinement
  - Capability for rapid expansion of features
- 50’ pneumatic mast
  - Ease of installation & maintenance
- Solar panel system
  - Off-grid power allows for flexible installation

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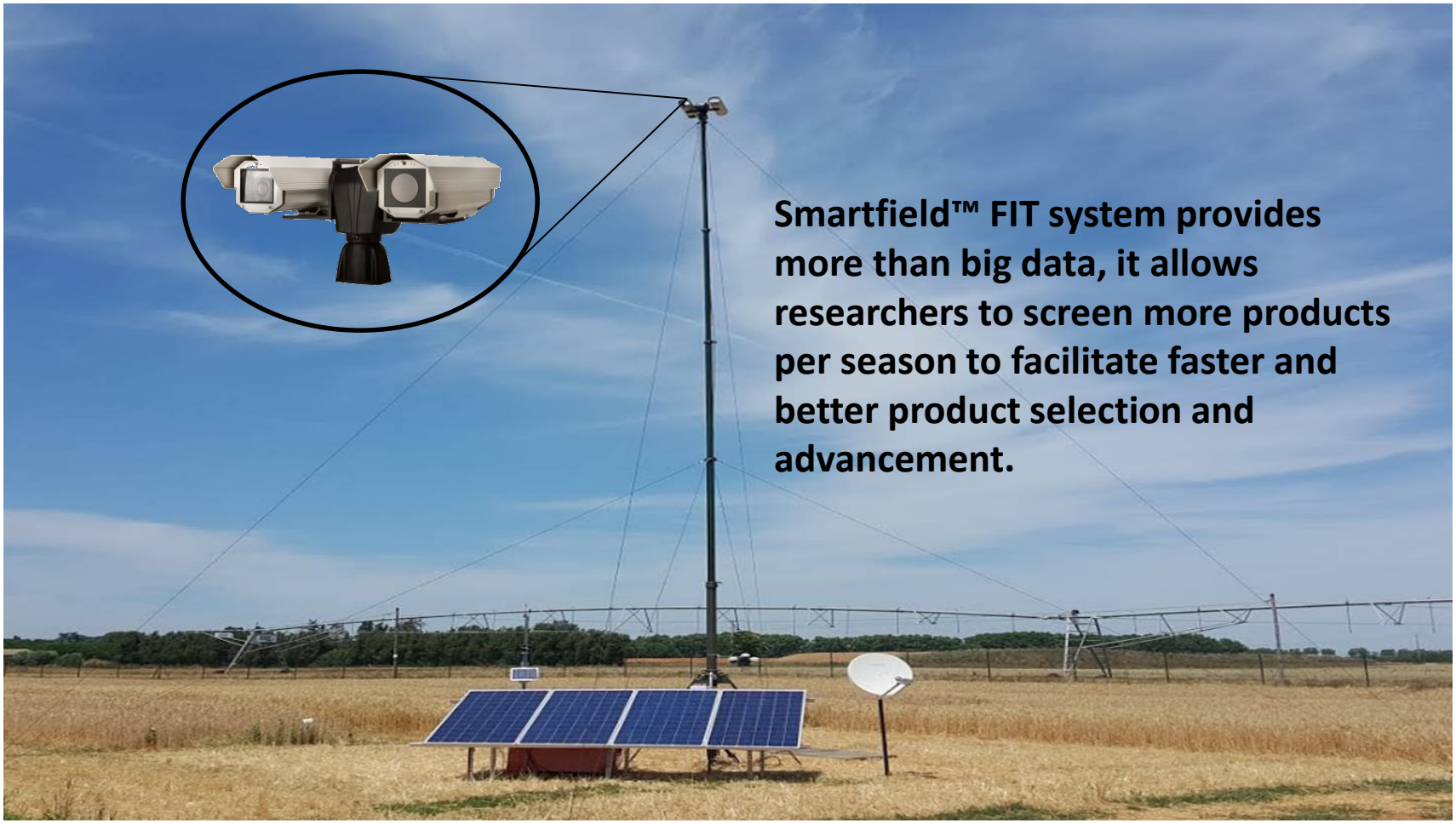
Smartfield™ FIT System



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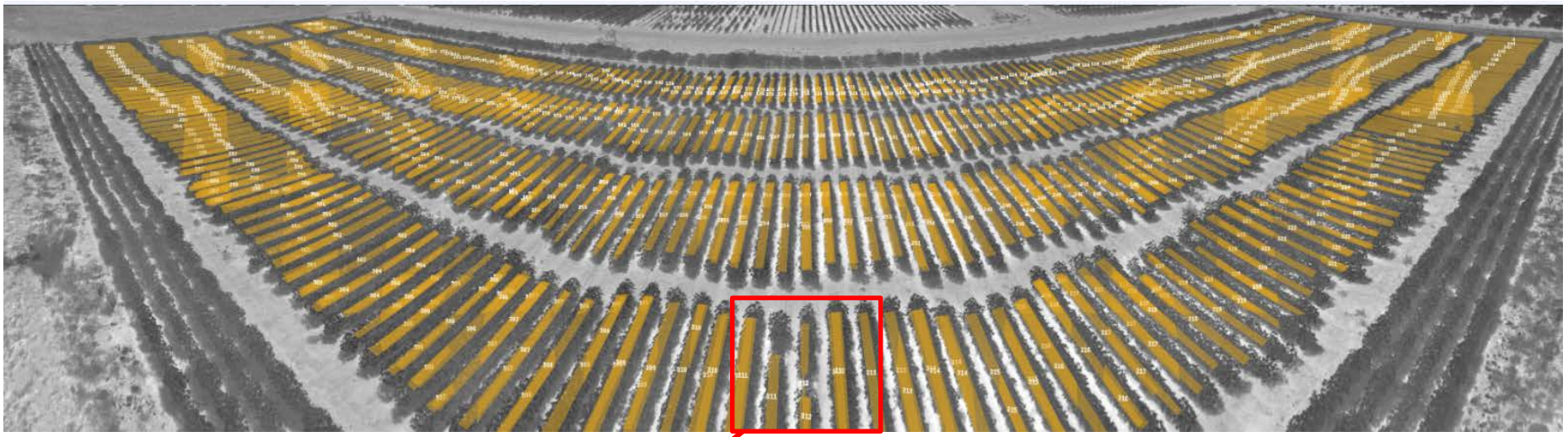
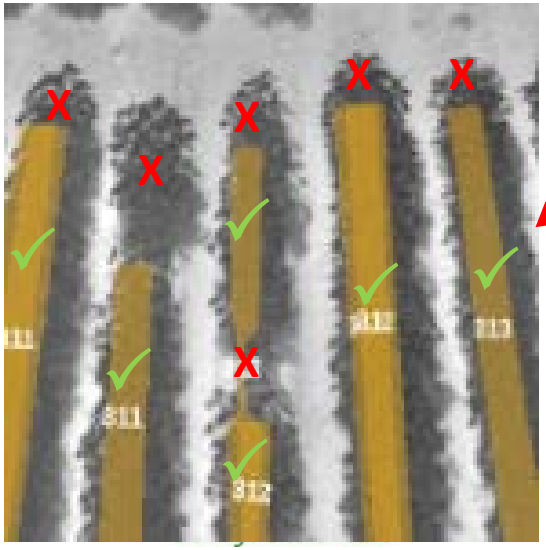
Smartfield™ FIT System Methodology

Area of Measurement (AOM)

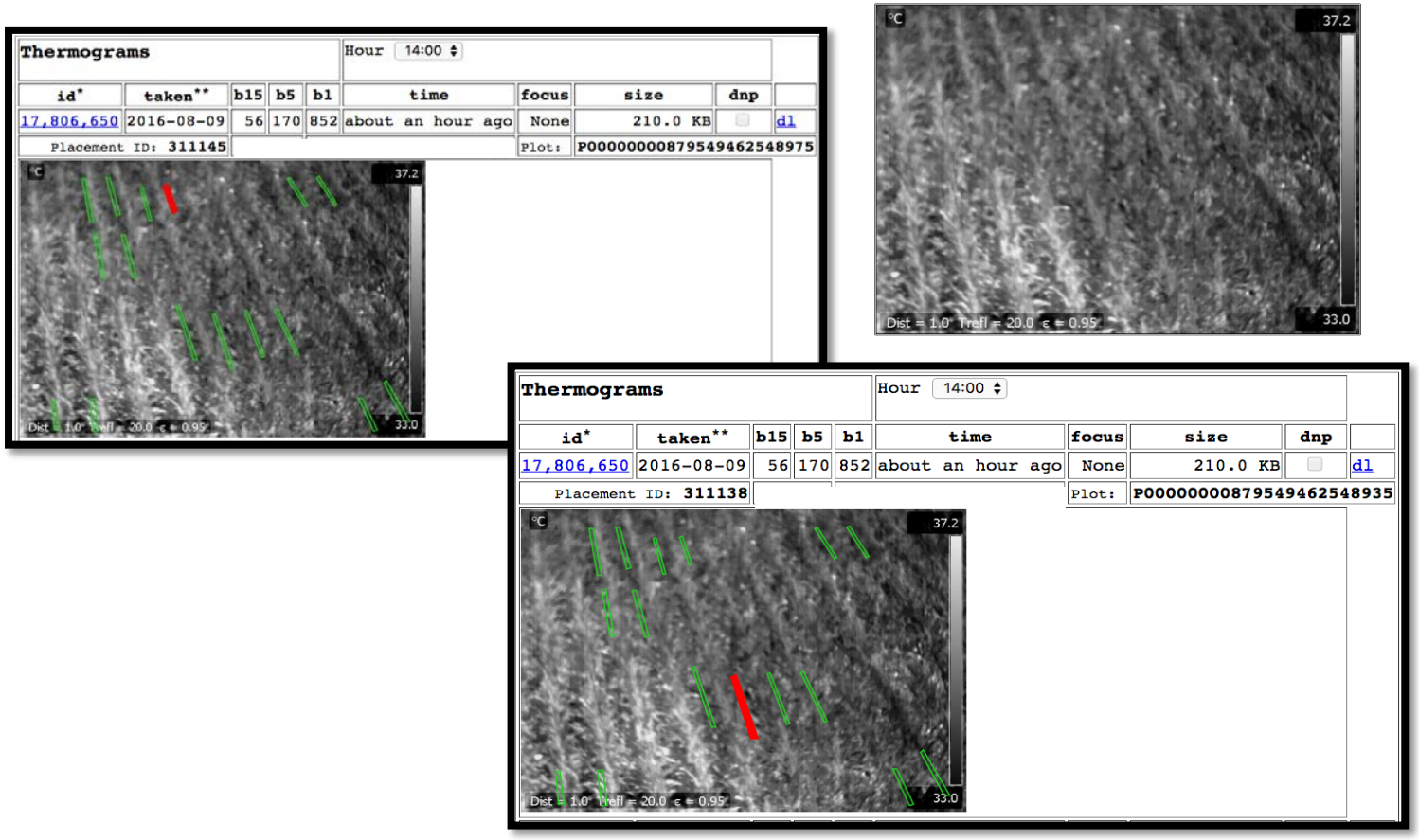




Data Captured…Smartfield automatically extracts the data from previously determined AOMs and parses it into a database

Smartfield™ FIT System Methodology

Image Processing and Pixel Assignment



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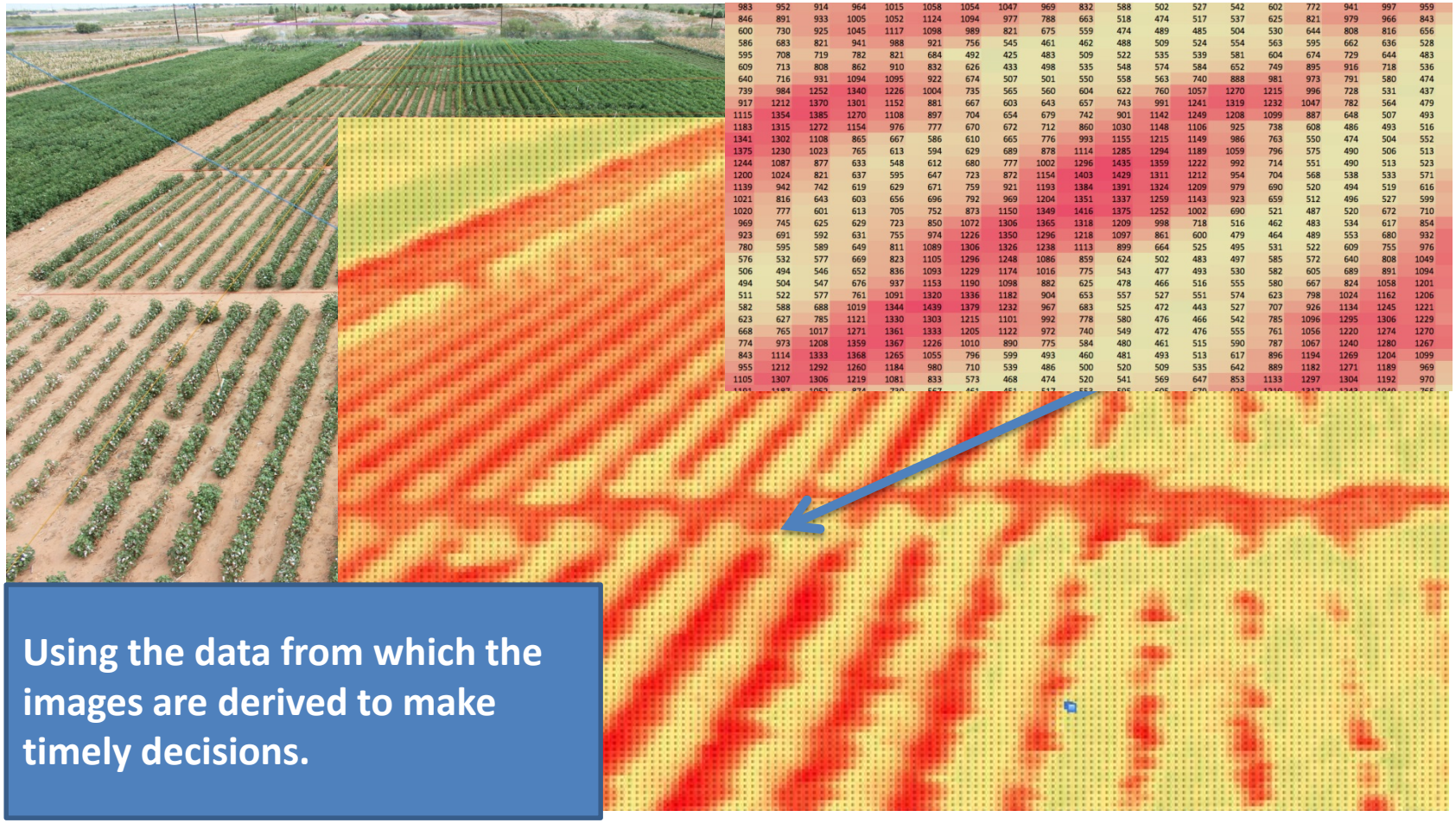
Smartfield™ FIT System Methodology

Panoramic Thermal Overview



Using the data from which the images are derived to make timely decisions.

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Smartfield™ FIT System Methodology

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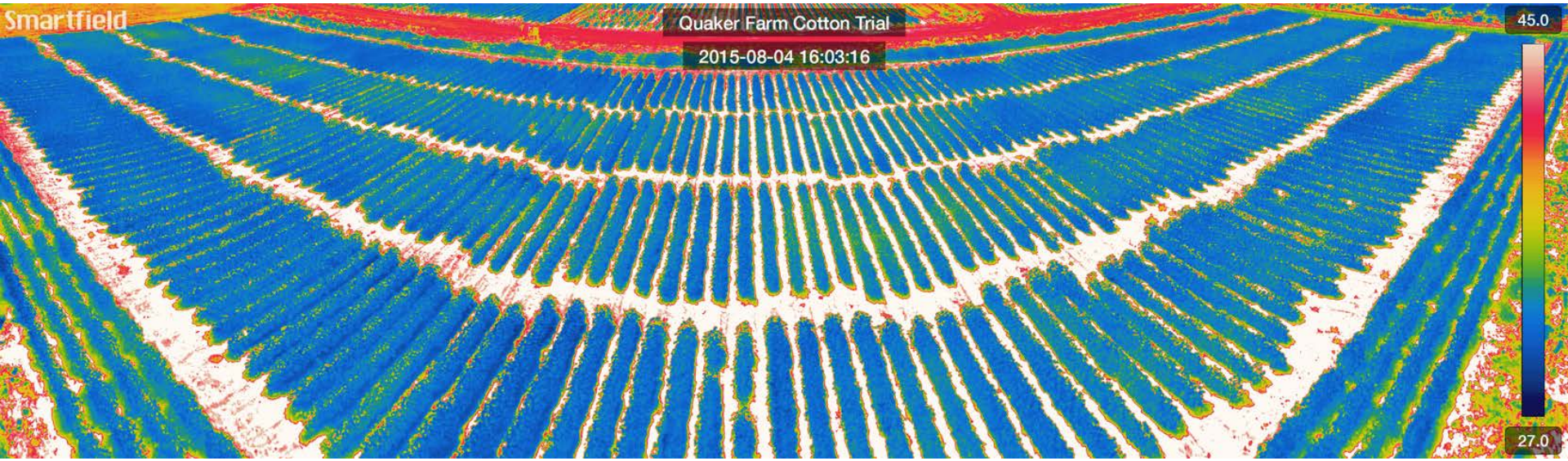

(Blue = Less Stress; Red = More Stress)

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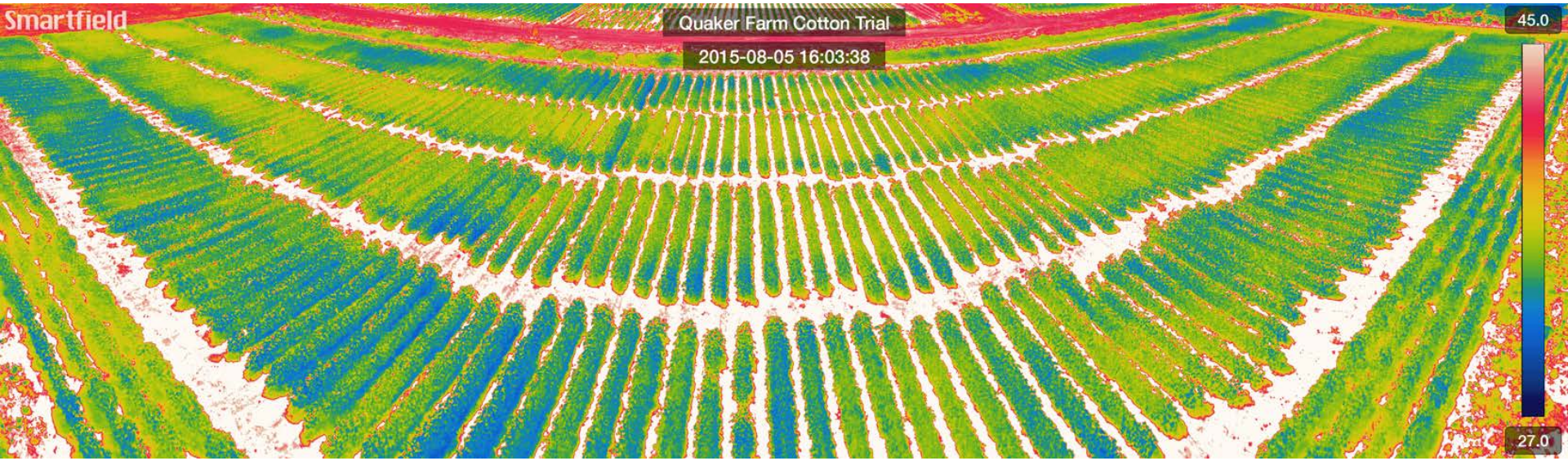

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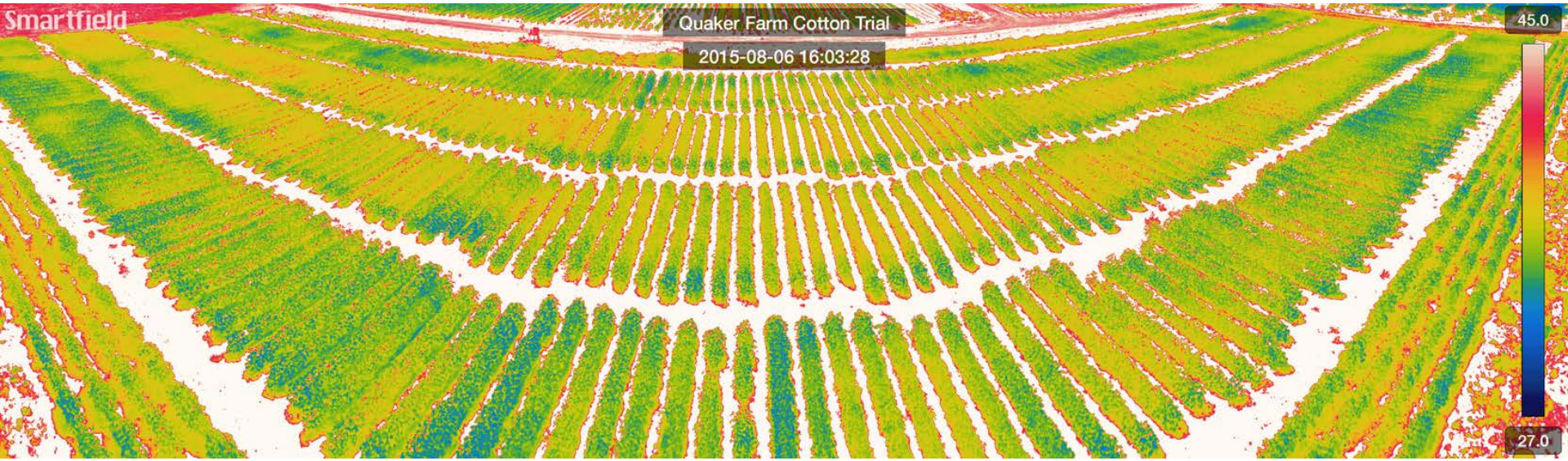

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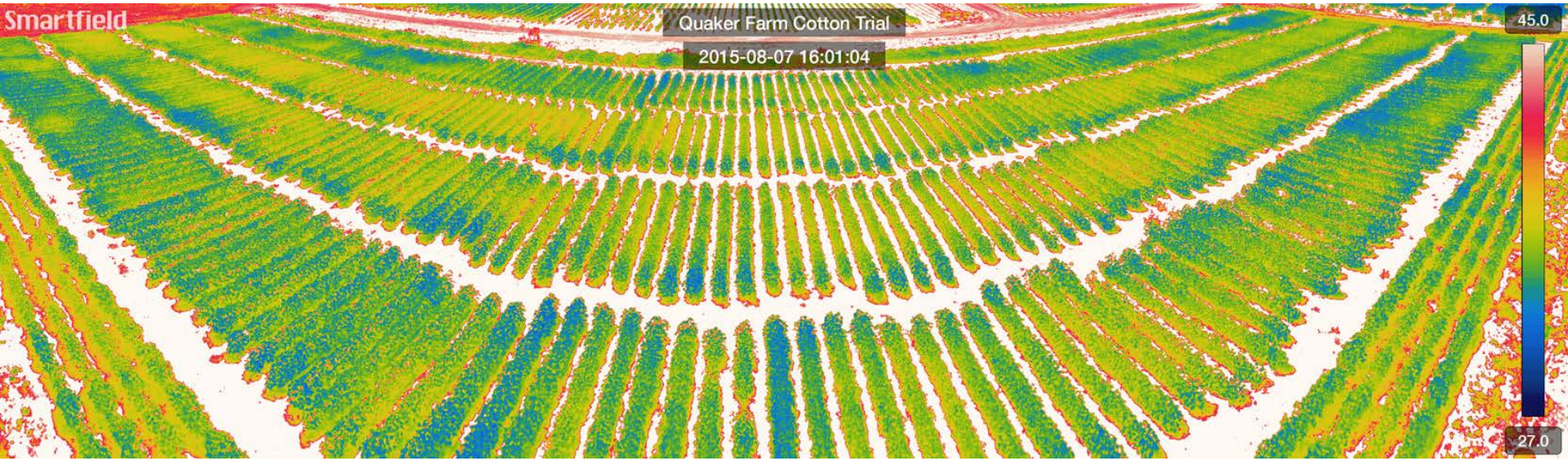

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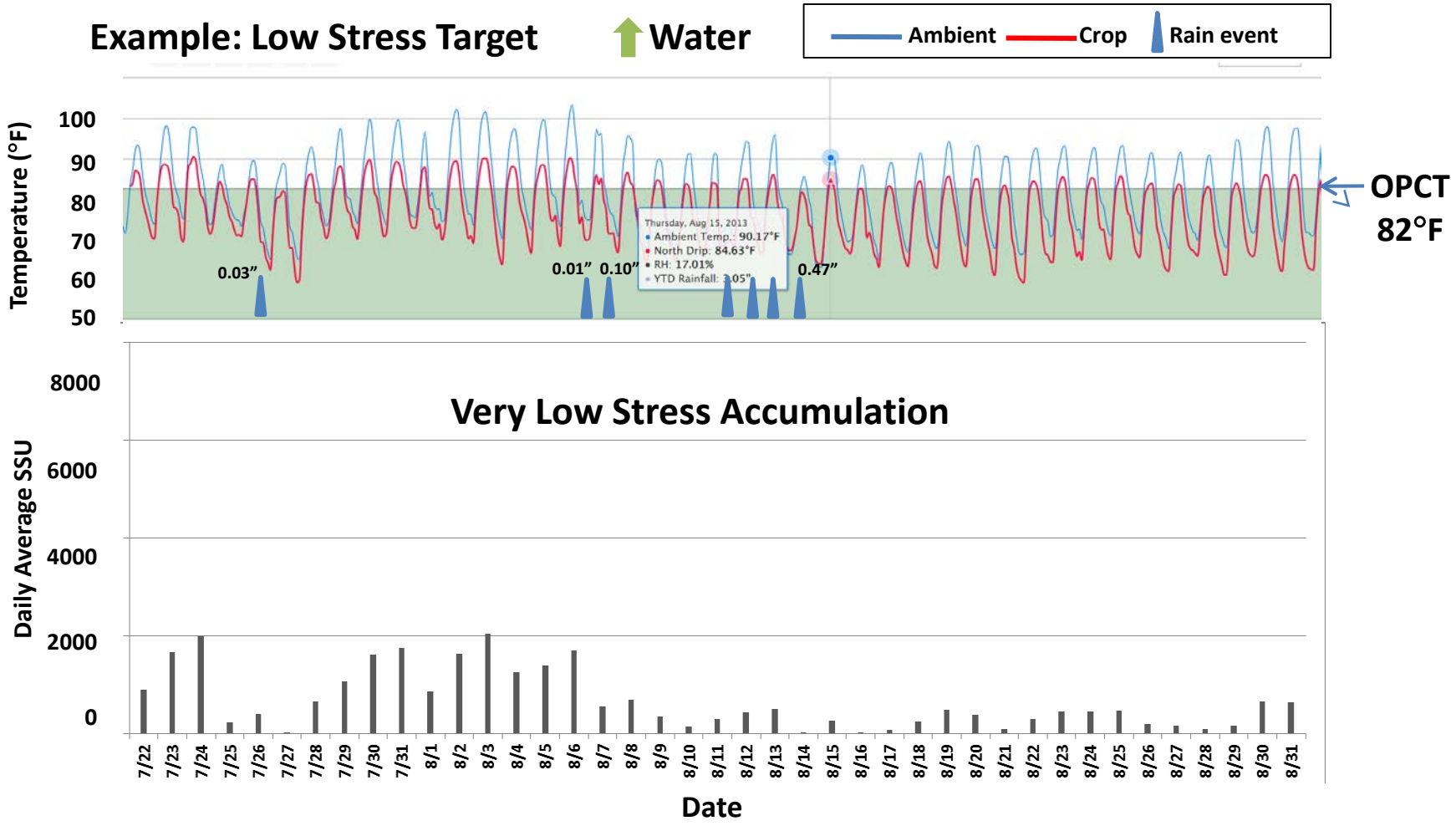
Smartfield™ FIT System Uses

Commercial Crop Management



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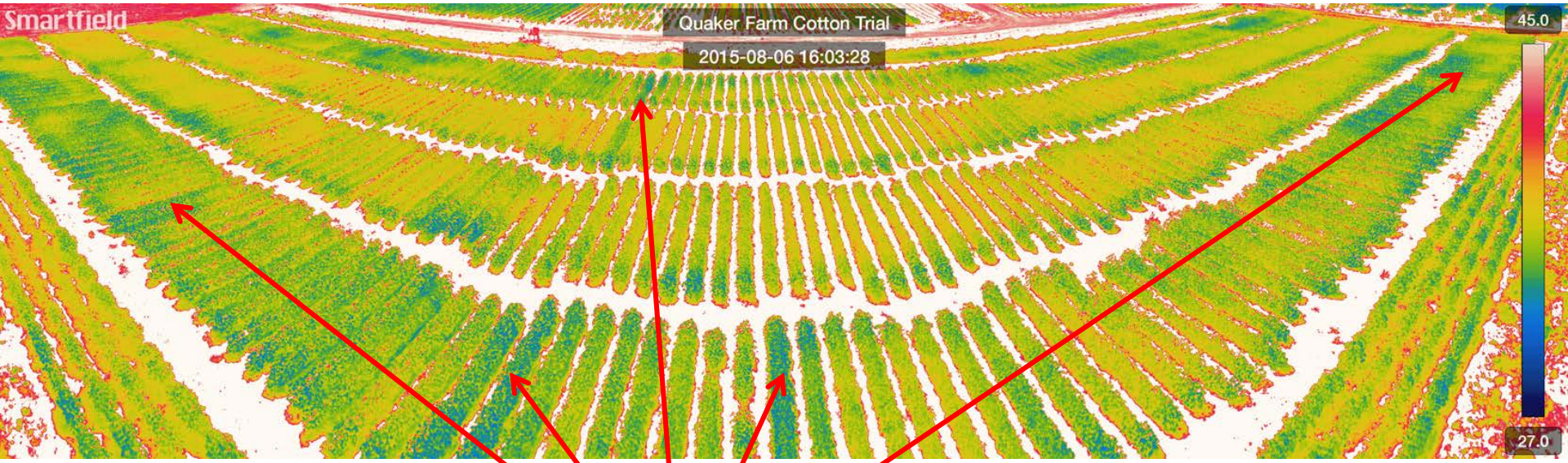
Smartfield™ FIT System Uses

Genotype Comparison



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Smartfield identifies strongest performers early in the season and facilitates product selection before yield assessment for faster overall product advancement

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Smartfield™ FIT System Uses

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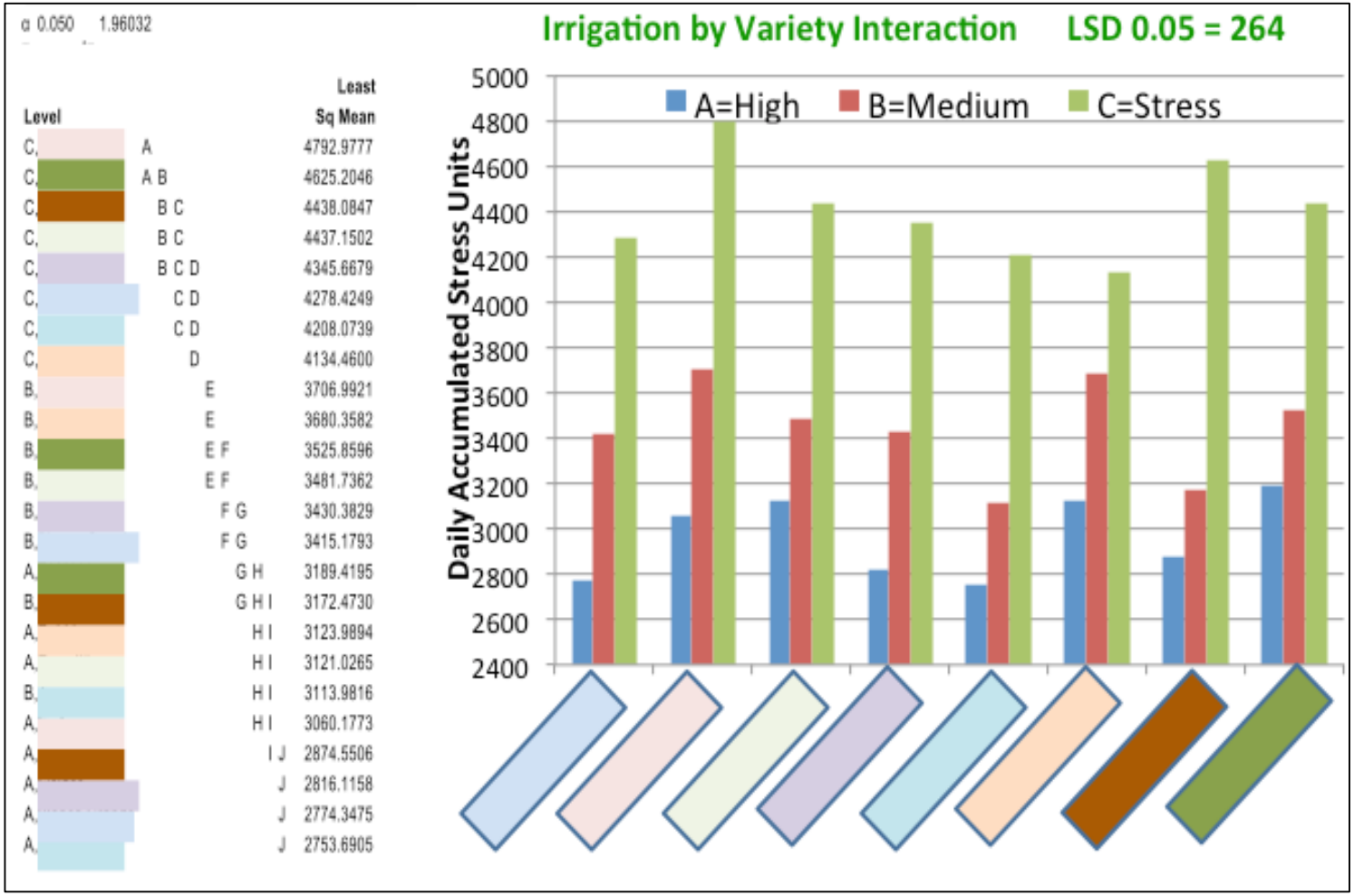

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Smartfield™ FIT System Uses
Disease Screening

- Typically diseases affect vascular tissues which ultimately restrict water movement and result in higher canopy temperatures
- Susceptible entries showed elevated canopy temperatures 4-7 days prior to visual symptoms
- Diseases detected: Sudden Death Syndrome (soy), *Fusarium* and *Verticillium* (cotton)

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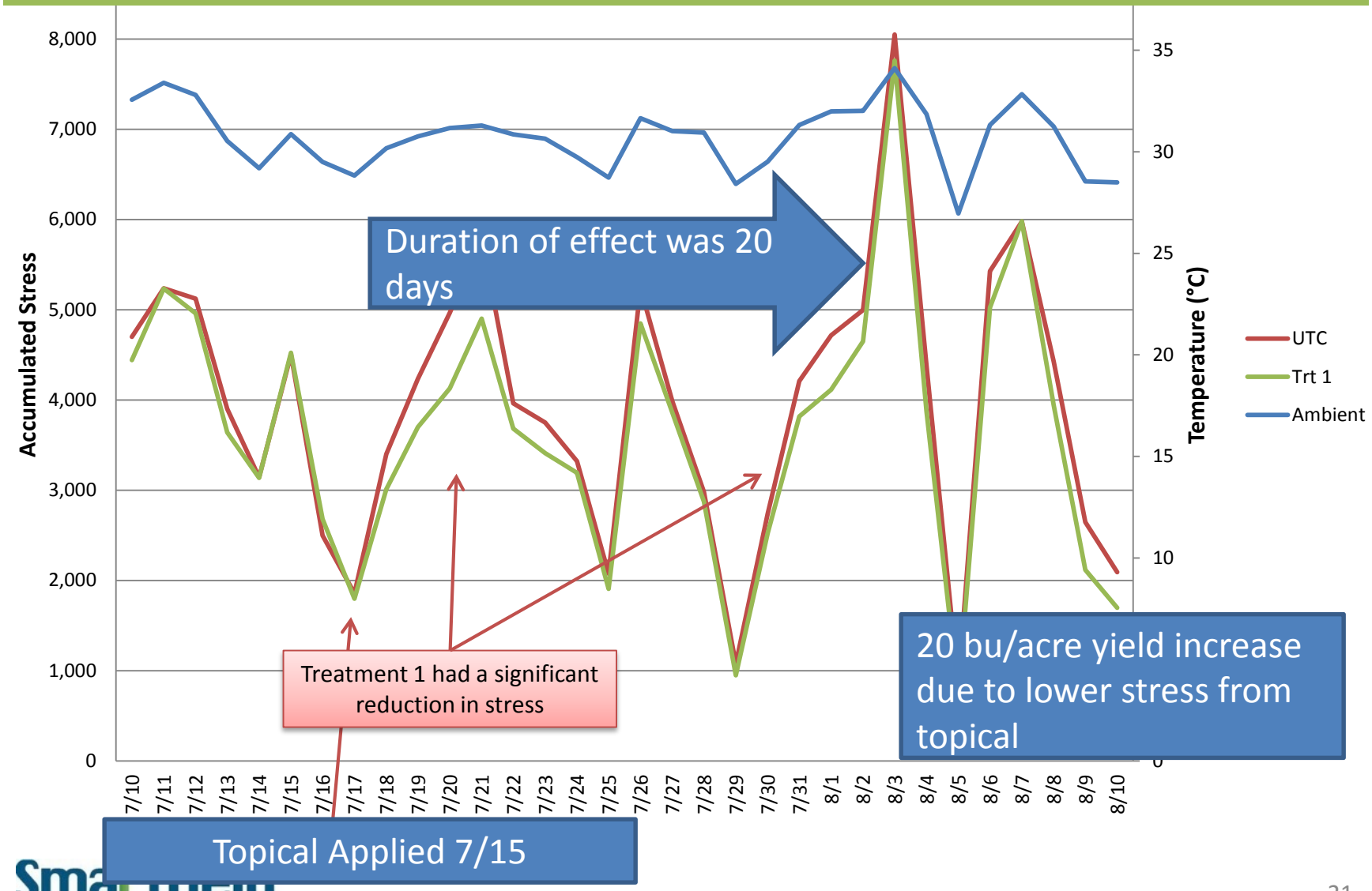
Smartfield™ FIT System Uses

Topical Applications



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Summary

- Plant canopy temperature is a reliable predictor for high throughput phenotyping
  - Genotype, irrigation, fertilization, chemical and biological treatments
  - Treatment screening from greenhouses to field to product positioning
- Smartfield Stress Unit (SSU) is an unbiased predictor of plant performance unaffected by plant population and harvesting equipment variability
- Smartfield™ FIT System can determine product performance well ahead of harvest
- Smartfield™ FIT System is an efficient research and crop management tool
  - System can monitor row crops, fruit trees, nut trees, vineyards, etc.

Smartfield Facilitates Faster Decisions Using Plant Canopy Data

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https://www.youtube.com/watch?v=pldvLV0xjmg
https://www.youtube.com/watch?v=kBQOUO2hDBg

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