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AG 20/20 PROJECT IN CALIFORNIA: ADAPTING REMOTE SENSING TECHNOLOGY TO COTTON PRODUCTION

J. Ojala
Shafter Research & Extension Center
USDA-ARS
Shafter, CA
S. Ustin
Center for Spatial Technologies and Remote Sensing
University of California
Davis, CA
N. Gat
Opto-Knowledge Systems, Inc.
Torrance, CA
B. Roberts
University of California Cooperative Extension
Hanford, CA
B. Taylor
Beeline Technologies
Fresno, CA
W. DeTar and J.V. Penner
Shafter Research & Extension Center
USDA-ARS
Shafter, CA
R. Plant
Department of Agronomy and Range Sciences
University of California
Davis, CA
M. Bethel
NASA
Stennis Space Center, MS
L. Godfrey
Department of Entomology
University of California
Davis, CA
T. Sheely
AZCAL Management Company
Lemoore, CA

Abstract

The Ag 20/20 Project in California is a cooperative and diverse program effort with team members from public research, extension and agribusinness. The project's objective is to develop and test remote sensing technologies with on-farm demonstrations and field trials. The main site is located in Lemoore, CA, and contains 1,995 acres on twelve fields that are managed by a commercial farming operation. Satellite and airborne remote imagery were used to support fourteen projects in 2002.

Introduction

This article is a summary of a poster that was presented at the 2003 Beltwide Cotton Conferences, Memphis, TN. The Ag 20/20 Project in California is a cooperative multidisciplinary program that contains team members from the National Aeronautics and Space Administration (NASA), the United States Department of Agriculture (USDA) Agricultural Research Service (ARS), the University of California and UC Cooperative Extension, California State University, and several remote sensing and agribusiness commercial companies. A primary objective of the Ag 20/20 Project is to develop and field test the use of current and new remote sensing technology in managing farm operations associated with cotton production. Many trials and demonstrations on this project use remotely sensed vegetation and soil patterns as indicators of spatially variable conditions that reflect crop performance under commercial production conditions. The project encourages the use of site-specific applications to manage this field variability and thereby improve crop yield, fiber quality, and economic returns compared to conventional farming practices.

2002 Project Team and Cooperators

Tony Azevedo, Blair Ground Services, Lemoore, CA.
Richard Baumeister, Director Product Development, Resource 21, Englewood, CO.
Matt Bethel, Research Scientist, NASA, John C. Stennis Space Center, MI.
Florence Cassel S., Center for Irrigation Technology, Calif. State University, Fresno, CA.
William DeTar, Agricultural Engineer, USDA-ARS, Shafter, CA.
Nahum Gat, President, Opto-Knowledge Systems, Inc., Torrance, CA.
Larry Godfrey, Extension Entomologist, University of California, Davis, CA.
Nick Gruenberg, Agronomist, Gruenberg Consulting, Hanford, CA.
Jim Hill, Agronomist, Hill Consulting, Lemoore, CA.
Bob Hutmacher, UCCE Extension Agronomist and Cotton Specialist, Shafter, CA.
Rodney McKellip, Project Manager, Commercial Remote Sensing Program, NASA, John C. Stennis Space Center
Dan Munk, Farm Advisor, UC Cooperative Extension, Fresno, CA.
John Ojala, Research Agronomist, USDA-ARS, Shafter, CA. (Project Manager)
Victor Penner, Engineering Technician, GPS-GIS, USDA-ARS, Shafter, CA.
Richard Plant, Professor, Dept. of Agronomy and Range Science, Univ. of California, Davis.
Bruce Roberts, Farm Advisor, UC Cooperative Extension, Hanford, CA.
Gordon Scriven, Opto-Knowledge Systems, Inc., Torrance, CA.
Ted Sheely, Cotton Grower, AZCAL Management Company, Lemoore, CA.
Tim Stone, Precision Ag Coordinator, Britz Fertilizer, Inc., Five Points, CA.
Brock Taylor, Applications Specialist, BEELINE Technologies, Inc., Fresno, CA.
Susan L. Ustin, Professor of Resource Science, Center for Spatial Technologies and Remote Sensing (CSTARS), University of California, Davis, CA. (Project Manager)
Michael Whiting, Strategic Planning, USDA-NRCS, Davis, CA.
Suling Zhao, Resource 21, Englewood, CO.

Location

The main Ag 20/20 Project site is located on the Sheely Farm (Fig. 1) near Lemoore, CA, and is operated by the AZCAL Management Company. Select fields in the nearby area have also been included in the project for demonstrations in detecting Lygus infestations and irrigation scheduling. In addition, fields on the Shafter Research & Extension Center (Fig. 2) have been included that demonstrate irrigation water management and pest (spider mite and aphid) detection. There are 24 fields at the main project location on the Sheely Farm. The fields range from 149 acres to 190 acres in size. All fields are surface irrigated using canal water. The soils are typically deep, neutral to high pH, clay loam texture, and often contain significant variability in soil salinity within fields. Fourteen fields (2,212 acres) of cotton were harvested in 2001 and twelve fields (1,995 acres) of cotton were within the main project site in 2002. Yield monitors were installed and calibrated on cotton pickers during the 2001 and 2002 harvests.

Remote Sensing

Hyperspectral, multispectral, and thermal infrared images were collected for all cotton fields on the project during the 2002 growing season (Table 1). AVNIR and SAMRSS cameras (Fig. 3 & 4) were mounted in a light airplane (Fig. 5) and flown across project fields during 12 flights from May to October, with weekly flights during July and August. Two calibration panels (light and dark reflectance) and thirty-two field corner markers were placed on the main project site and used for calibrating and georeferencing the remote images. The remote images and calculated vegetation indices were posted within twenty-four hours after each flight on the Project's Ag 20/20 website (www.ag2020.net). Additional data were provided by other airborne (AVIRIS) and satellite (ASTER, QuickBird, and Ikonos) remote sensing instruments.

Field Demonstrations and Research Trials

Fourteen field demonstrations and research trials were conducted during 2002 by project cooperators. The remote images were used for determining site-specific application rates for several major inputs, such as the growth regulator Pix, reclamation of saline soils, and cotton seeding rate. Other field projects used remote sensing to predict crop yield, assist with irrigation scheduling, estimate physical and chemical soil properties, and identify specific crop stresses (nitrogen, water, insect pests). The project also allowed the development of a rapid, automated image processing method to reduce the time and labor required to process (calibrate, georectify, georeference, trim) raw hyperspectral and multispectral image data. A Precision Ag Field Day was held on July 26 in Field 6-4 to introduce the ag community to remote sensing and precision ag technologies, and demonstrate how they can be used to make more efficient and effective management decisions, including variable rate applications, under commercial production.

2002 Field Trials and Demonstrations on the Ag 20/20 Project

1. **2002 Precision Ag Field Day** – held July 26th on field 6-4 with over 150 attendance. Speakers summarized the use of remote sensing imagery and variable rate technology on Ag 20/20 cotton fields. Many commercial vendors were present to demonstrate new equipment and technology.

2. **Variable Rate Application of Pix** – this is a demonstration and field trial that uses remotely sensed images to assign pix application rates for different areas within a field.

3. **Site-Specific Soil Salinity Management** – field trial that uses multispectral remote imagery of bare soil and several stages of canopy development to measure the effects of soil salinity on cotton yield.

4. **Soil Salinity Mapping for Variable Seeding Rate** – trials on fields 6-2 and 4-1 that use vegetative index maps and NIR reflectance of plant canopy to identify salinity problem areas within fields for variable rate cotton seed planting.

5. **Variable Rate Fertilizer Nitrogen Application** – this field trial will use multispectral imagery to estimate vegetative response to nitrogen fertilizer applications.

6. **Detection of Soil Properties with Remote Imagery** – the objective of this trial is to determine which soil physical (texture) and chemical (salinity, carbonates, pH) properties can be reasonably estimated using multispectral or hyperspectral remotely sensed imagery.

7. **Estimation of Cotton Yield** – spectral lines and algorithms using hyperspectral and multispectral remote image data will be correlated by acquisition date to cotton yield data.

8. **Prediction of Irrigation Scheduling Demand Based on Canopy Water Content and LAI** – this projects maps depth of water bands and uses radiative transfer models of leaf and canopy reflectance linked to a cotton yield model.

9. **Soil Organic and Inorganic Carbon, Saline-Sodic Salts, and Moisture Contents of the Surface of Bare Soils** – this project evaluates the ability of remotely sensed imagery to estimate soil organic matter, carbonates, sodic minerals and clay content.

10. **Water vs. Nitrogen Stress Differentiator in Cotton** – an objective of this project is to develop indices that differentiate between N stress and water stress in cotton.

11. **Irrigation Scouting** – this demonstration will identify an optimal irrigation scouting technique using remote imagery by comparing several indices, including NDVI, WI, SAVI, tussled cap index, and others.

12. **Testing of Commercialization Techniques** – explores low cost commercial techniques for atmospheric compensation, georegistration, rectification, and full automated processing of remotely sensed images.

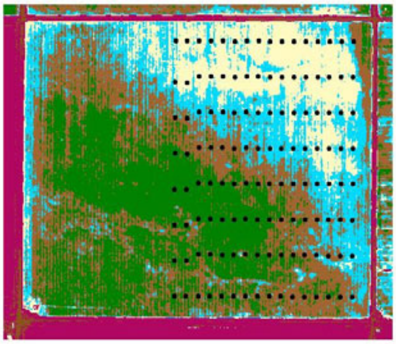
13. **Use of Remote Sensing to Facilitate Insect and Mite Pest Management Decision-Making** – this demonstration will use NDVI and remote imagery as an aid to identify lygus bug and other pest populations within a field.

14. **Cotton Variety Trials** – twelve approved Acala varieties and six approved Pima varieties in a replicated trial on fields 6-1 and 32-2.

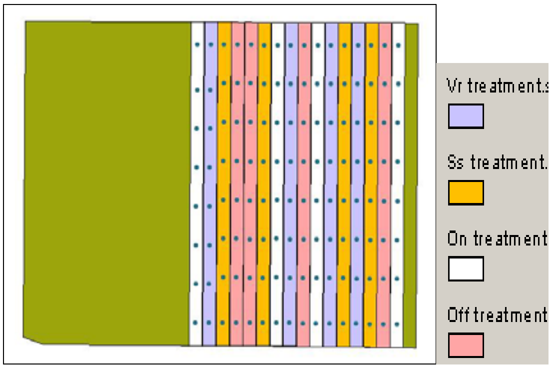
Brief Description of Trial #2: Variable Rate Application of Pix to Cotton (
by M. Bethel, NASA, Stennis Space Center, MS

Multispectral image of Field 5-4 on July 8th used to gene-rate Pix prescription map.

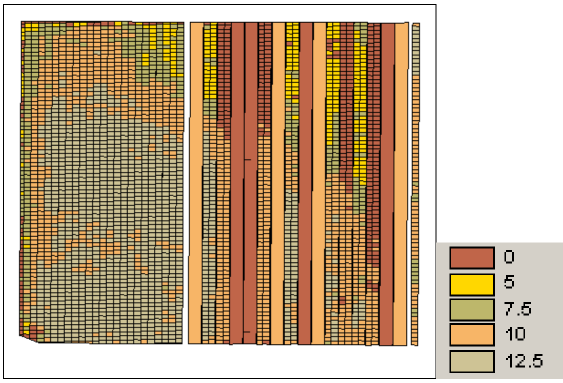
The variable rate treatments were determined through discriminant analyses in SAS to find the image processing technique that best correlated with estimated Pix rates. The estimated Pix rates were determined with a Pix Recommendation Chart using the field data collected at each sampling point on the 8th and 9th of July. The image processing technique that was determined to have the best correlation with the estimated Pix rates was NDVI+(Red/NIR).



Classified NDVI image (from July 8th flight) with sampling points overlaid (used for scouting) to determine site-specific treatment threshold.



Experimental setup with sampling points overlaid.



Pix Rate in Gallons/Acre

Field 5-4 Pix prescription (applied July 15).

Acknowledgements

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Table 1. Instruments used to collect remote images on the Ag 20/20 Project.

		Resolution		
Instrument[a]	**Platform**	**Spectral**	**Ground**	**Source**[b]
ASTER	satellite	VNIR (bands 1 - 3)	15 m	NASA,
		SWIR (bands 4 – 9)	30 m	Jet Propulsion
		TIR (bands 10-14)	90 m	Laboratory
AVNIR	airborne	400 - 1100 nm	0.8 m	OKSI
AVIRIS	airborne	400 - 2500 nm	4 & 20 m	NASA,
				Jet Propulsion
				Laboratory
IKONOS				
panchromatic	satellite	450 – 900 nm (pan)	1 m	Space Imaging
multispectral	satellite	450 – 520 nm (blue)	4 m	
		520 – 600 nm (green)		
		632 – 698 nm (red)		
		757 – 853 nm (NIR)		
SAMRSS				
multispectral	airborne	545 – 555 nm (green)	1 m	USDA-ARS,
		675 – 685 nm (red)	<2 m	OKSI
		830 – 870 nm (NIR)		
thermal IR	airborne	8 – 14 microns		
QuickBird				
multispectral	satellite	445 – 900 nm (pan)	0.6 m	Resource 21
	satellite	450 – 520 nm (blue)	2.4 m	(DigitalGlobe™)
		520 – 600 nm (green)		
		630 – 690 nm (red)		
		760 – 900 nm (NIR)		

[a]ASTER: Advanced Spaceborne Thermal Emission and Reflection Radiometer
AVNIR: Airborne Visible Near Infrared instrument
AVIRIS: Airborne Visible/infrared Imaging Spectrometer
SAMRSS: Shafter Airborne Multispectral Remote Sensing System

[b]NASA: National Aeronautics and Space Administration
OKSI: Opto-Knowledge Systems, Inc.

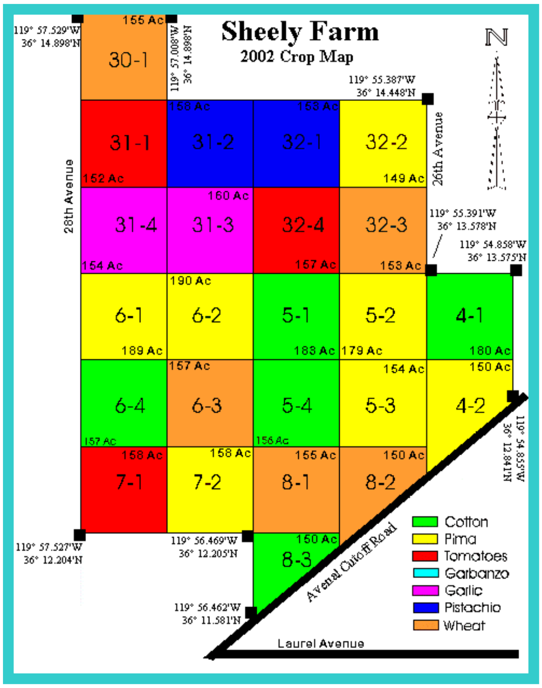

Figure 1. 2002 crops and fields on the AZCAL Farm site, Lemoore, CA.

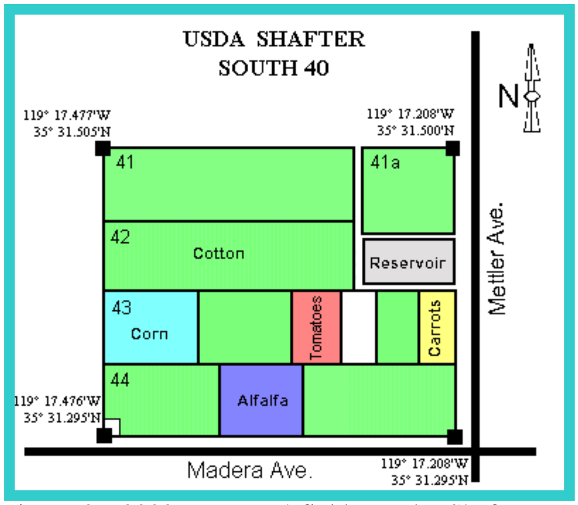

Figure 2. 2002 crops and fields on the Shafter Research Station Site, Shafter, CA.

Figure 3. SAMRSS camera system.

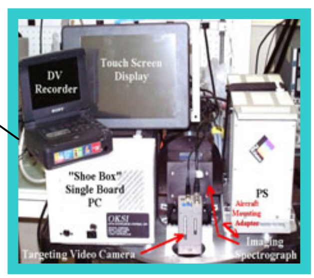

Figure 4. AVNIR camera system.

Figure 5. Cessna airplane used for conducting flights with multispectral and hyperspectral cameras.