Crop Models for Decision Support

James W. Jones
University of Florida

November 7, 2000

Crop Models in Research and Practice:
A Symposium Honoring Professor Joe T. Ritchie
American Society of Agronomy Annual Meeting
Minneapolis, MN

Crop Models for Decision Support

- Some Success Stories
  - Research and Technology Transfer (DSSAT)
  - Australian Applications using APSIM
  - Soybean Industry-Led Applications in the USA
  - Farmer-Led Applications in Argentina
  - Sugarcane Industry Model Uses in South Africa
  - Others…
- Characteristics for Success
- Challenges
- Trends

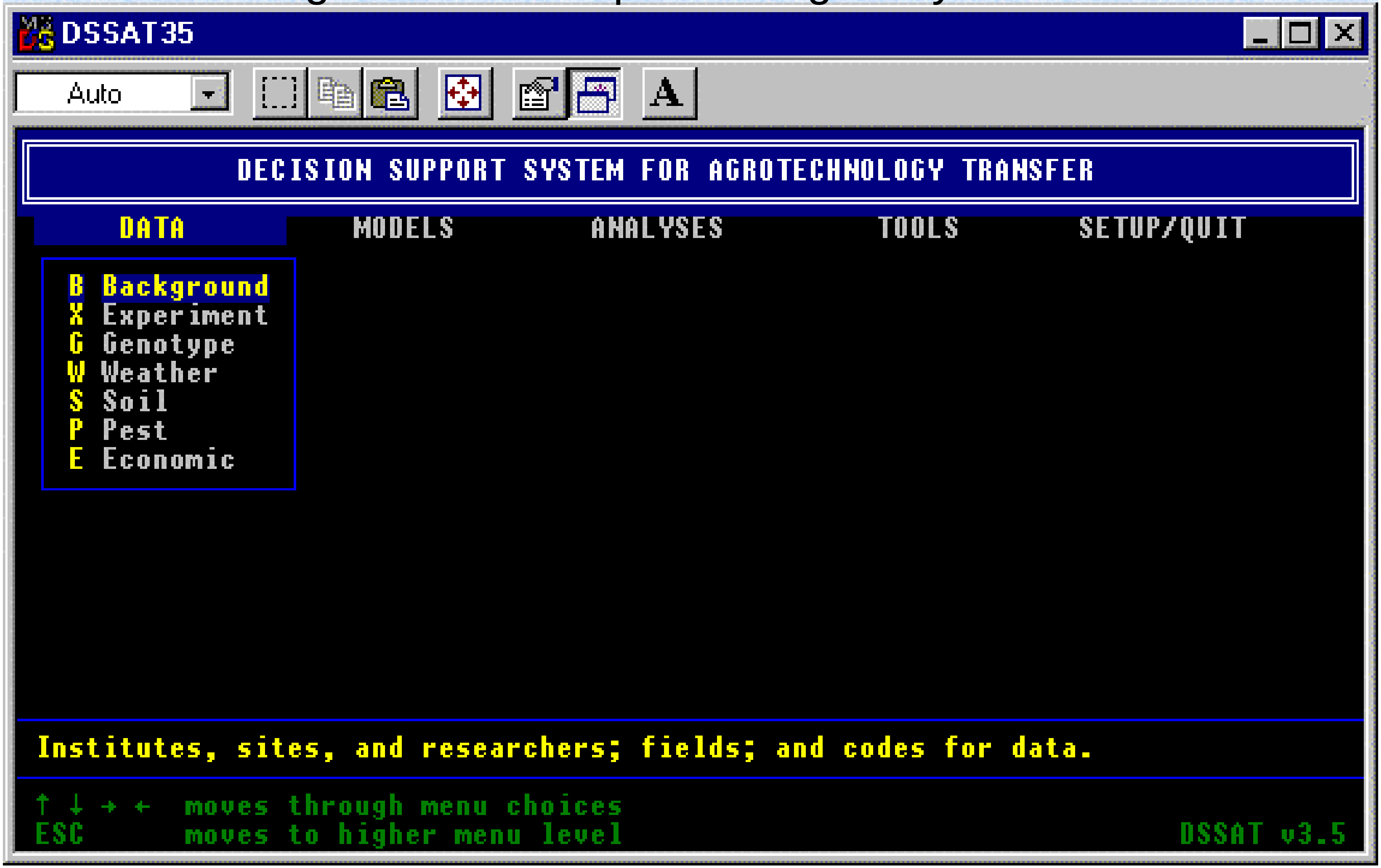
Research & Technology Transfer

- USAID Project, 1983-93 (IBSNAT)
- DSSAT, Field-Scale DSS
  - Biophysical Models (Crop, Soil, Weather), 17 Crops
  - Risk Analysis (Biophysical and Economic)
  - Data Entry and Manipulation Tools
  - Utilities (graphics, data entry, management,…)
  - Crop Rotation Analyzer
- GIS Spatial Analysis Products
  - GIS-DSSAT Linkage for Region Impact Assessment
  - GIS Precision Agriculture Analyzer
- Targeted for use by Researchers

Research & Technology Transfer: Process

- Network of research users testing and applying models
- Network of developers contributing models, analysis tools, utilities, & data
- Minimum data set defined
- Standard formats, protocols for use, exchange
- Packagers, maintainers, distributors
- Trainers

DSSAT v3.5 screen showing DATA, MODELS and ANALYSES sections. Data must be entered for weather, soil, and management before performing analyses.



DSSAT Applications

- Climate Change Effects on Crop Production
- Optimize Management using Climate Predictions
- Interdisciplinary Research, Understand Interactions
- Diagnose Yield Gaps, Actual vs. Potential
- Optimize Irrigation Management
- Greenhouse Climate Control
- Quantify Pest Damage Effects on Production
- Yield Forecasting
- Precision Farming
- Land Use Planning, Linked with GIS

Impacts

- Adopted by ~ 1500 researchers in 90 countries
- Impacts of climate change; used in > 8 national & international projects worldwide
- Hundreds of applications independent of developers
- Spawned teams on every continent, still active
- Validated systems approach for technology transfer
- Still in use


APSIM shell - Brian Keating
APSIM
Agricultural Production
Systems Simulator
CSIRO
Australia
APSRU
DPI
Copyright © 1994 Agricultural Production Systems Research Unit

Crop, pasture and tree modules

Currently available

- **Maize**
- **Wheat**
- **Barley**
- **Sorghum**
- **Sugarcane**
- **Sunflower**
- **Canola**
- **Chickpea**
- **Mungbean, Cowpea, Soybean**
- **Peanut**
- **Stylo pasture**
- **Lucerne**
- **Cotton (OzCot)***
- **Native pasture (GRASP)**
- **Hemp**
- **Pigeonpea@**

Under development

- **Lentil / faba beans***
- **GRAZPLAN***
- **Millet @**
- **Lupin***
- **FOREST #**

* by arrangement with CSIRO Plant Industry

@ in association with ICRISAT

In association with CSIRO L&W

From Brian Keating, 2000

APSIM Applications

"Discussion Support System"

Exploring *what if* questions:

- Which crop to sow?
- When to sow?
- How much N to apply?
- Which variety to sow?
- What density?
- Analysis of different starting conditions and seasonal forecasts

From Brian Keating, 2000

Private Sector: United Soybean Board

Goals

- Evaluate potential for practical, on-farm uses of soybean model for decision support
- Create a sustainable process for soybean production technology transfer, tailored to specific fields for optimizing profits
- Integrate new research results into the system, enhancing its capabilities in ways important to farmers
- Researchers in eight states

USB
UNITED SOYBEAN BOARD
Making Your Checkoff Pay Off.

Early Experience

- Overly ambitious
- Under estimated time, complexities of process
- Conflicting objectives in design
- Changing computer technologies
- Changing model
- Failure of a first prototype
- "… Can researchers really do this?", But...
- Input from farmers, industry provided guidance for success

What We Did

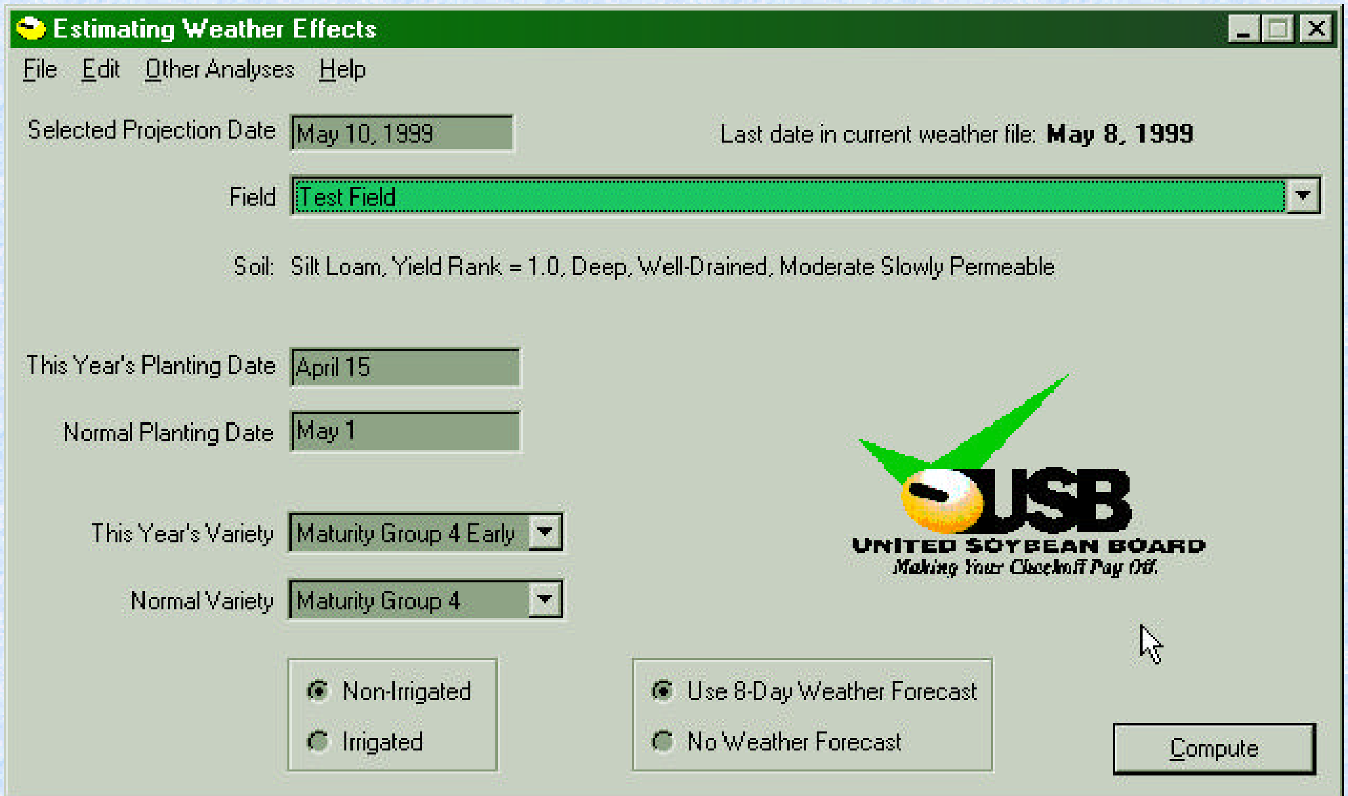
- Packaged soybean model with data on soils, weather access to provide information for:
  - production planning (planting, weed control, variety, planting date, irrigation, profitability)
  - in-season decisions (irrigation, re-plant, yield forecast)
- Worked with farmers, farmer advisors, industry to refine design and test
- Independent evaluation by researchers in a number of states, and by industry
- Demonstrated value of approach for integrating new research aimed at specific problems identified by farmers

PCYield

- Simple, targeted, graphical user interface
- CROPGRO-Soybean simulation model
- Field-specific data management
- Internet access to weather data
- Production risk indicators
- In-season yield projections
  - Compare varieties, planting dates, re-plant decisions
  - Irrigation timing, yield impacts

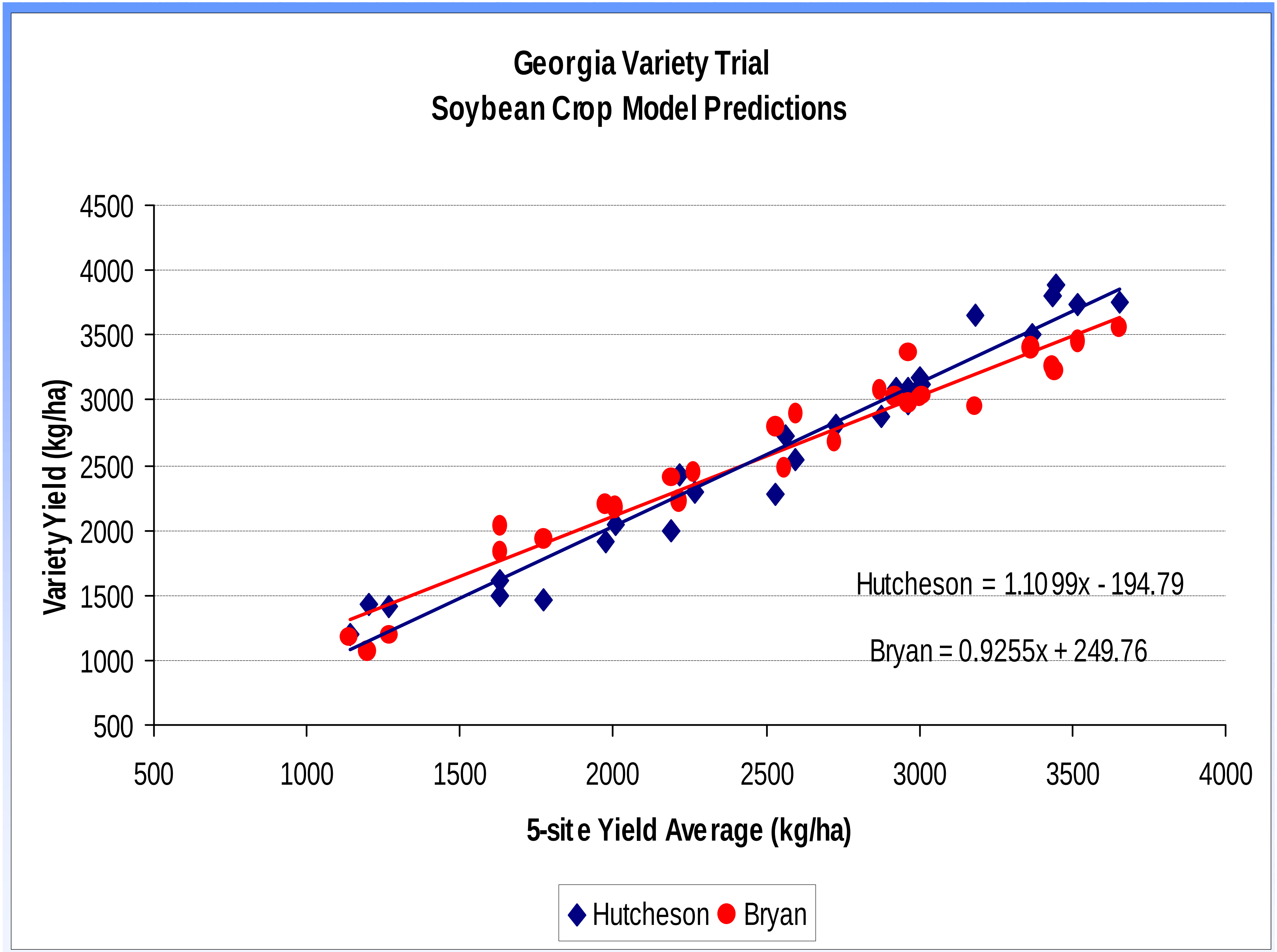
UNITED SOYBEAN BOARD
Making Your Checkoff Pay Off.

All Needed Data Available



Targeting Research to Fill Gaps: Ability to analyze commercial varieties

Develop and test methods for estimating genetic coefficients of new varieties as they are released, using yield trial data


Georgia Variety Trial
Soybean Crop Model Predictions
Variety Yield (kg/ha)
4500
4000
3500
3000
2500
2000
1500
1000
500
500
1000
1500
2000
2500
3000
3500
4000
5-site Yield Average (kg/ha)
Hutcheson = 1.1099x - 194.79
Bryan = 0.9255x + 249.76
Hutcheson
Bryan

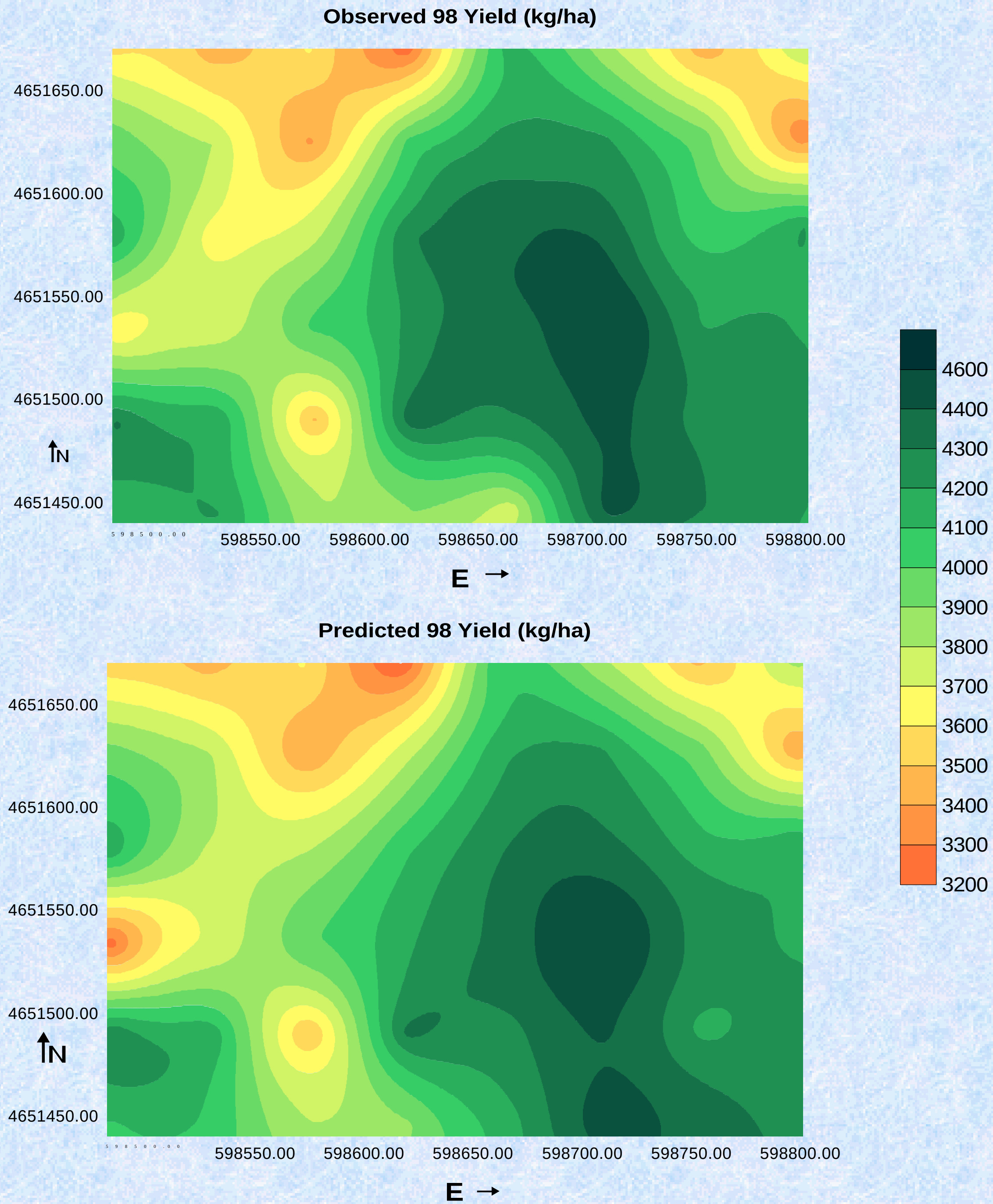
Targeting Research to Fill Gaps: Precision Agriculture

The Problem:

- Yield varies considerably in many fields
- Spatially varying inputs and management may increase profits and reduce environmental risks

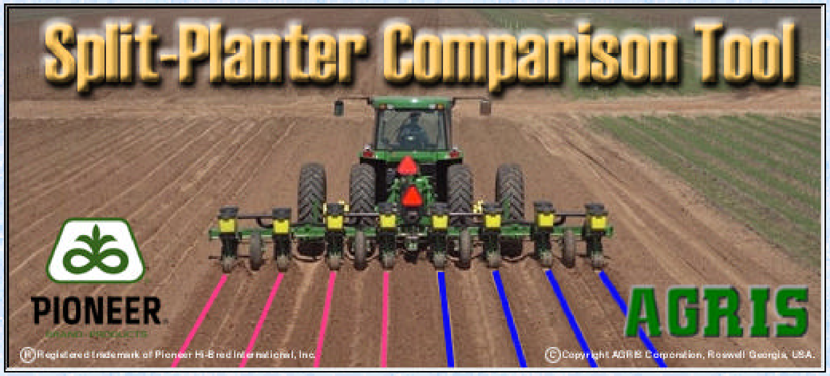
However:

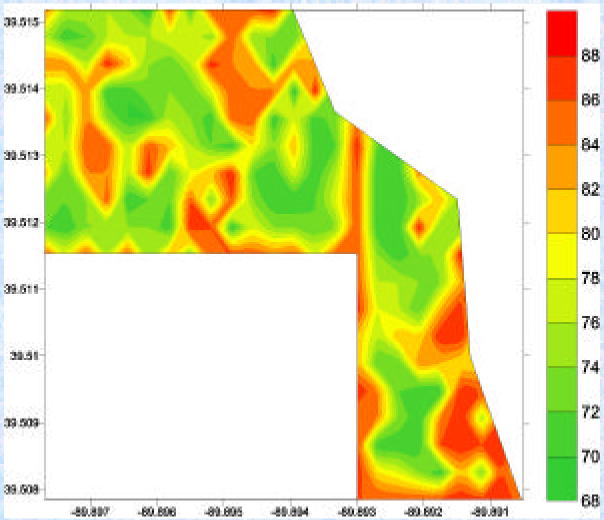
- Quantifying what caused yield variability in a specific field is not easy
- How does one determine how to vary management across a field to optimize profit and meet other goals?

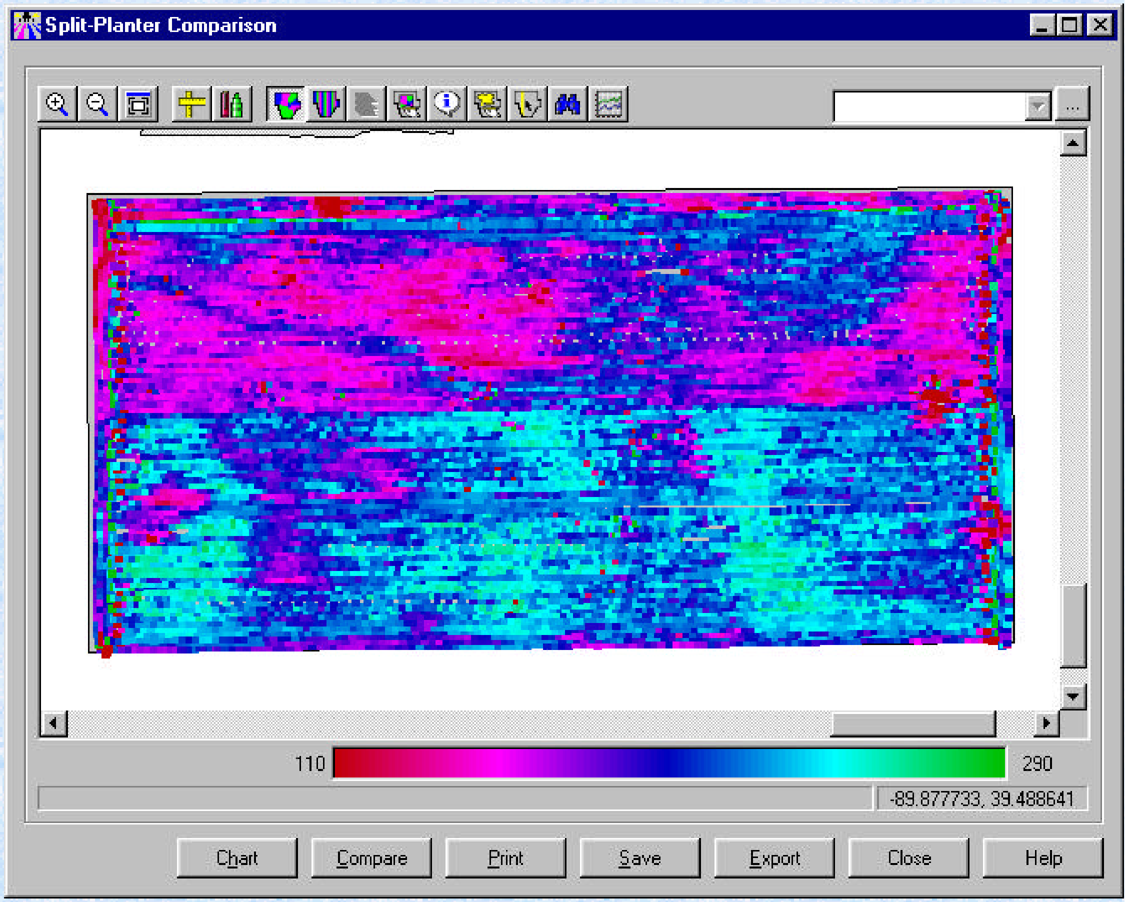


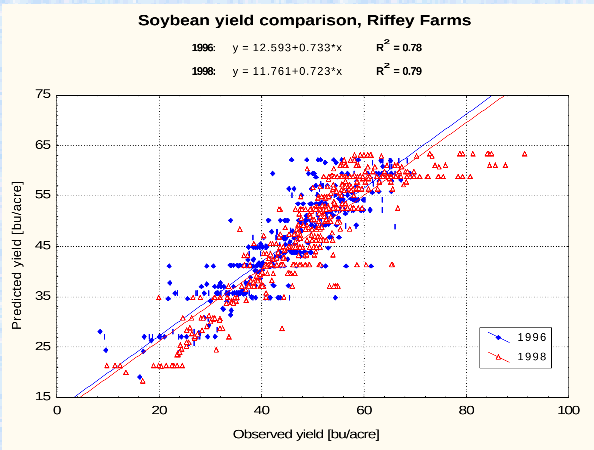
A. Irmak et al., 2000
Keiper Field, Iowa

Working with Industry for Adoption









A. Ferreyra et al., 2000
Riffey Field, Illinois

Characteristics of Successful Efforts

- Address issues of interest to targeted users (farmers, researchers, policy makers)
- Target users are clearly identified
- Direct involvement of users, intermediaries (input, service suppliers; extension, researchers)
- Interdisciplinary teams
- Easy access, use (usually by intermediaries, not farmers or policy makers themselves)
- Availability of necessary input data
- Open process for evaluation, discussion, design, use
- Model credibility, process to assess credibility

Challenges

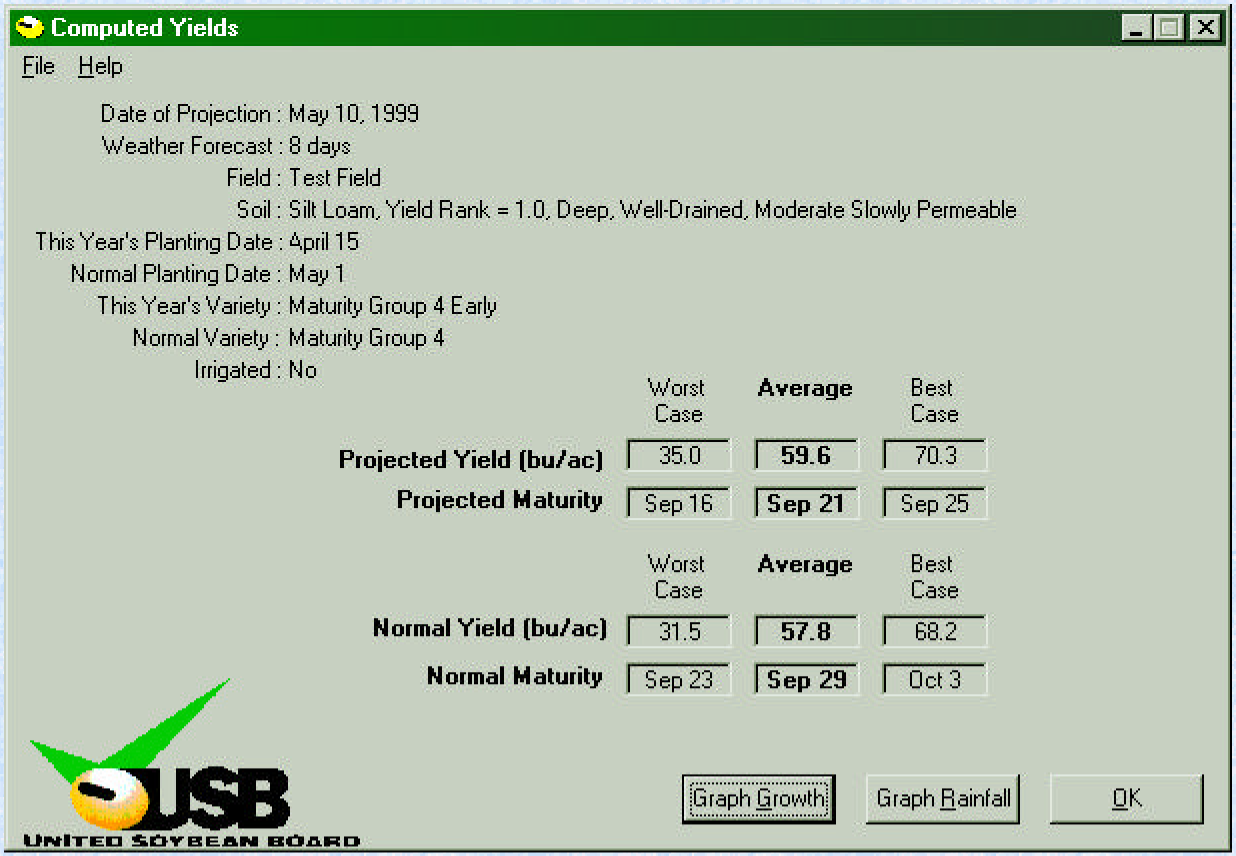
- It is much more difficult than originally thought, even if models were perfect
- Models do not include many factors important for decision support
- It is difficult to include other factors, mainly due to difficulty of measuring inputs needed for those factors
- Are our current institutions adequate?
- Complexity of upgrading models
- Intellectual property rights
- Public – private sector cooperation
- Documentation, maintenance

Trends

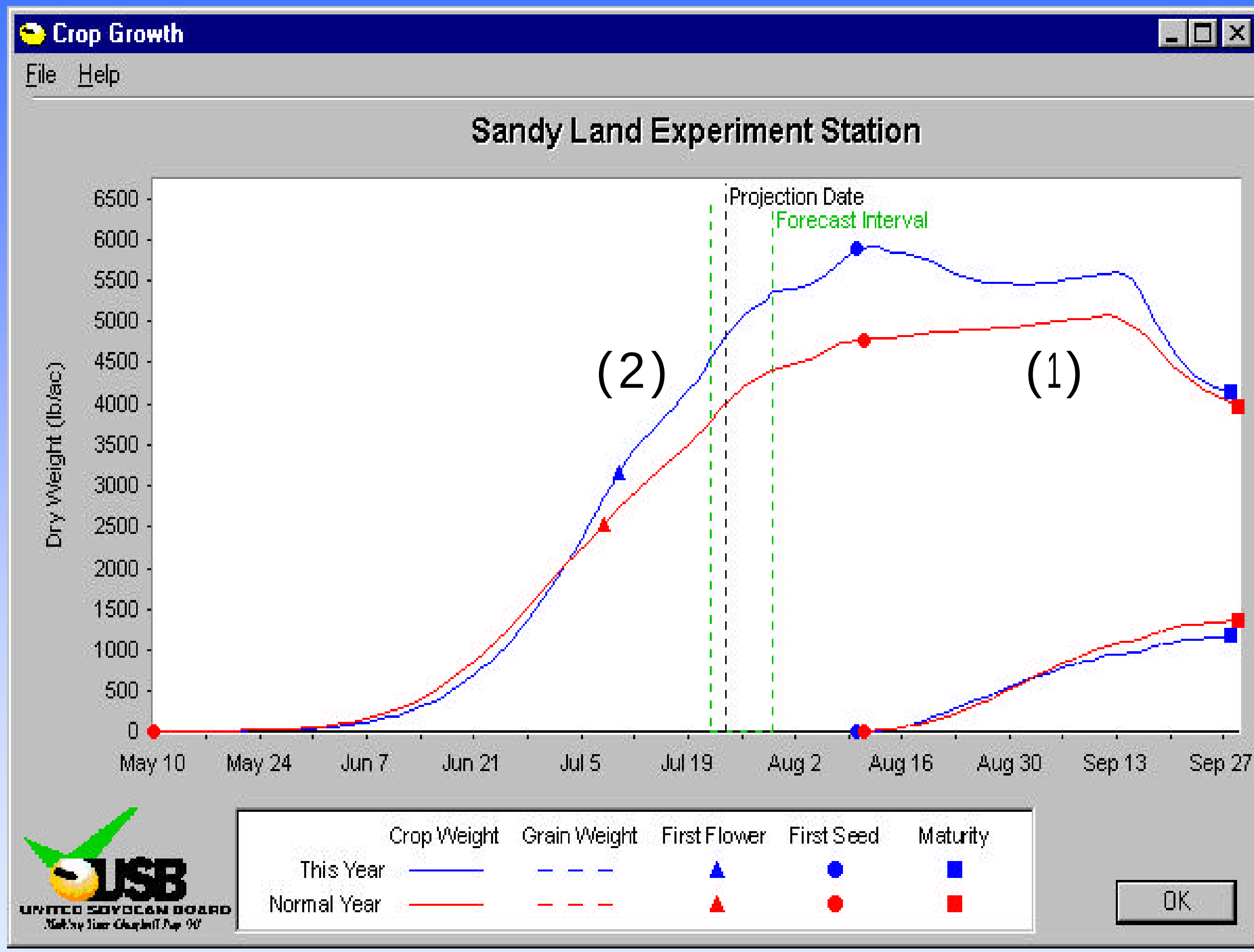
- Industry interest, capabilities
- Increasing capabilities for measuring inputs
- Modular model design, software engineering
- Balanced models with more components
- Flexible designs for tailoring model to specific needs
- Increasing student interest, contributions to components
- Long term investments in process
- More cooperation in model development, evaluation
- Internet tools

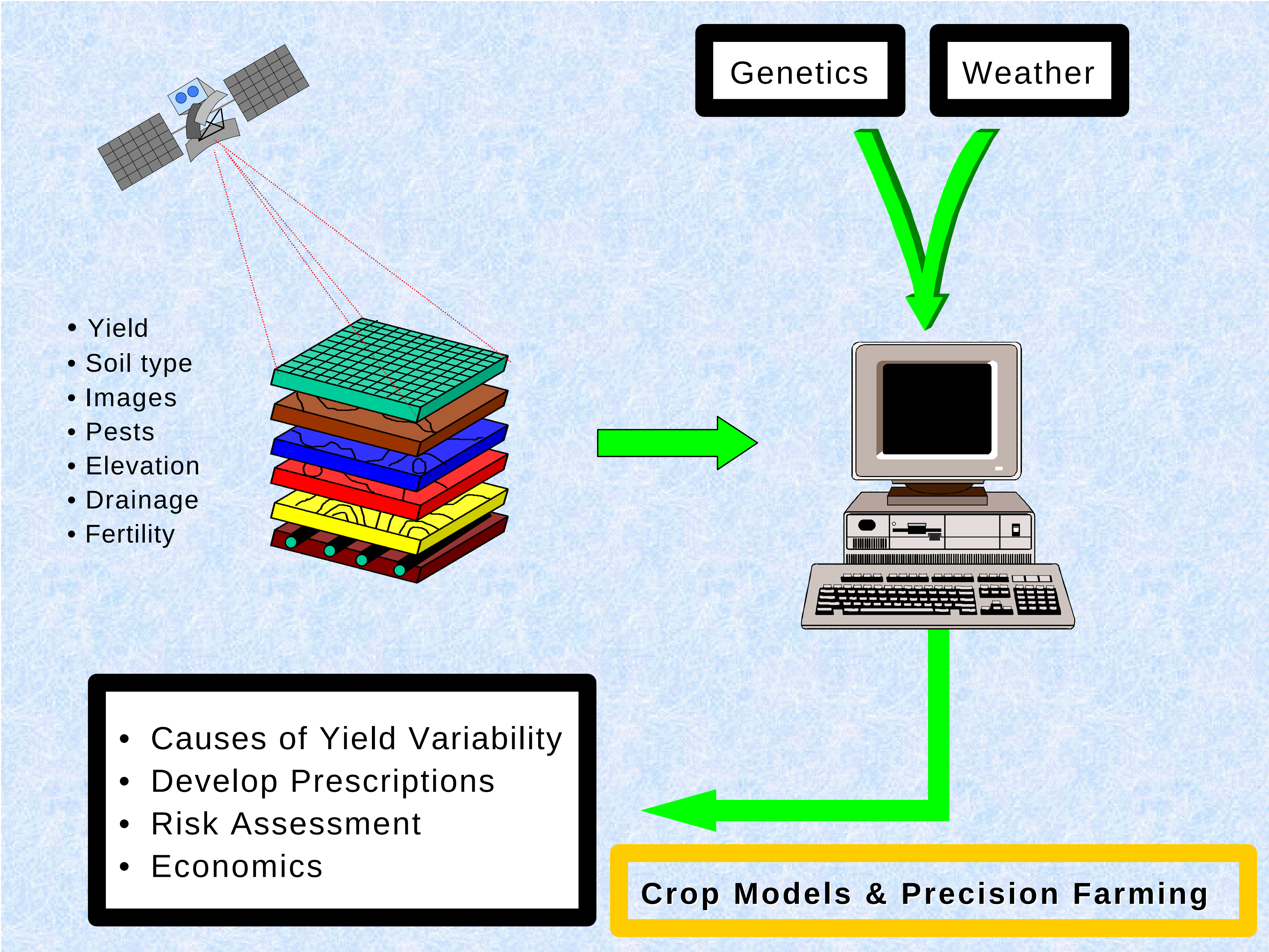

Thank You

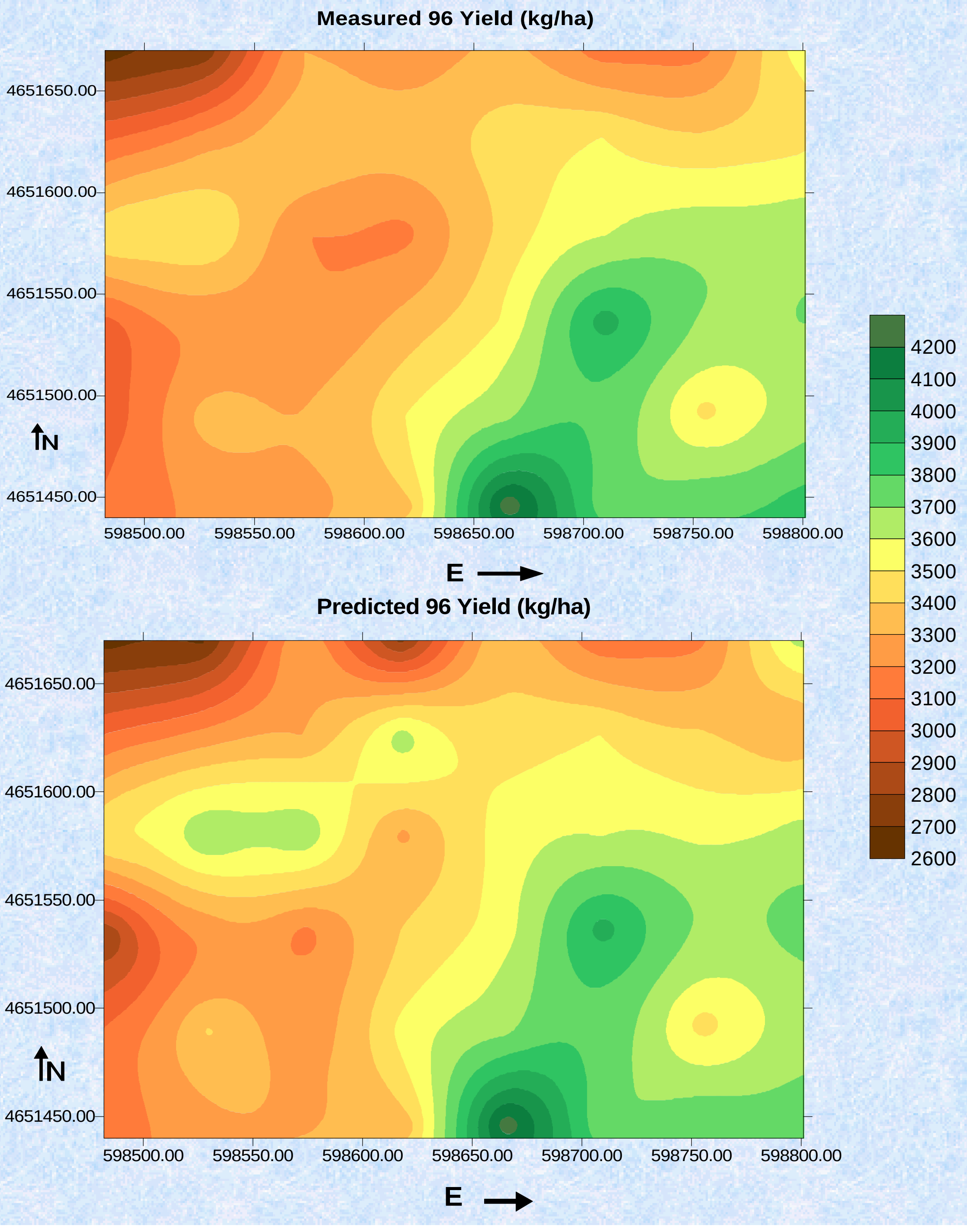
Predicted Results



Predicted growth: (1) Average of 10 years, (2) This year




Genetics
Weather
• Yield
• Soil type
• Images
• Pests
• Elevation
• Drainage
• Fertility
• Causes of Yield Variability
• Develop Prescriptions
• Risk Assessment
• Economics
Crop Models & Precision Farming



A. Irmak et al., 2000
Keiper Field, Iowa

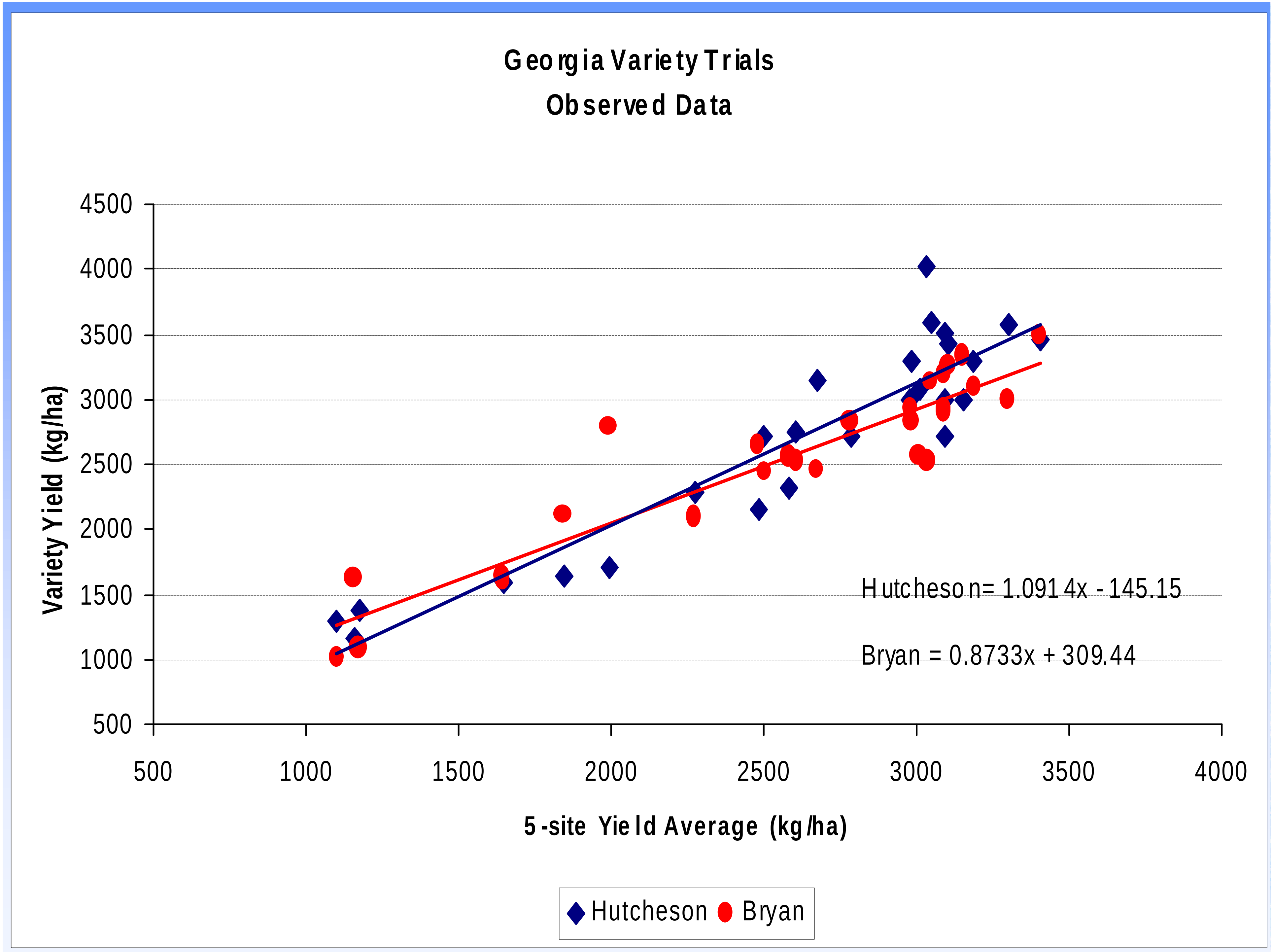
ICASA

International Consortium for Agricultural System Applications

- Network of individuals and institutions
- Cooperating to facilitate development and application of systems approaches and tools
- To affect decisions & policies related to human interactions with natural resources

Implications: Need for Toolkit

- Models, Analysis Tools
  - Projective, Exploratory, Predictive
  - Different scales, purposes
  - Building block, modular approach
- Data
  - Minimum data set, indicators
  - Standard formats, protocols
  - Natural resources, Socioeconomic
- Purposes
  - Assessment
  - Management, Decision Aids
  - Conflict Resolution
- Wide distribution, easy access
- International effort, ICASA, CG Centers, etc.

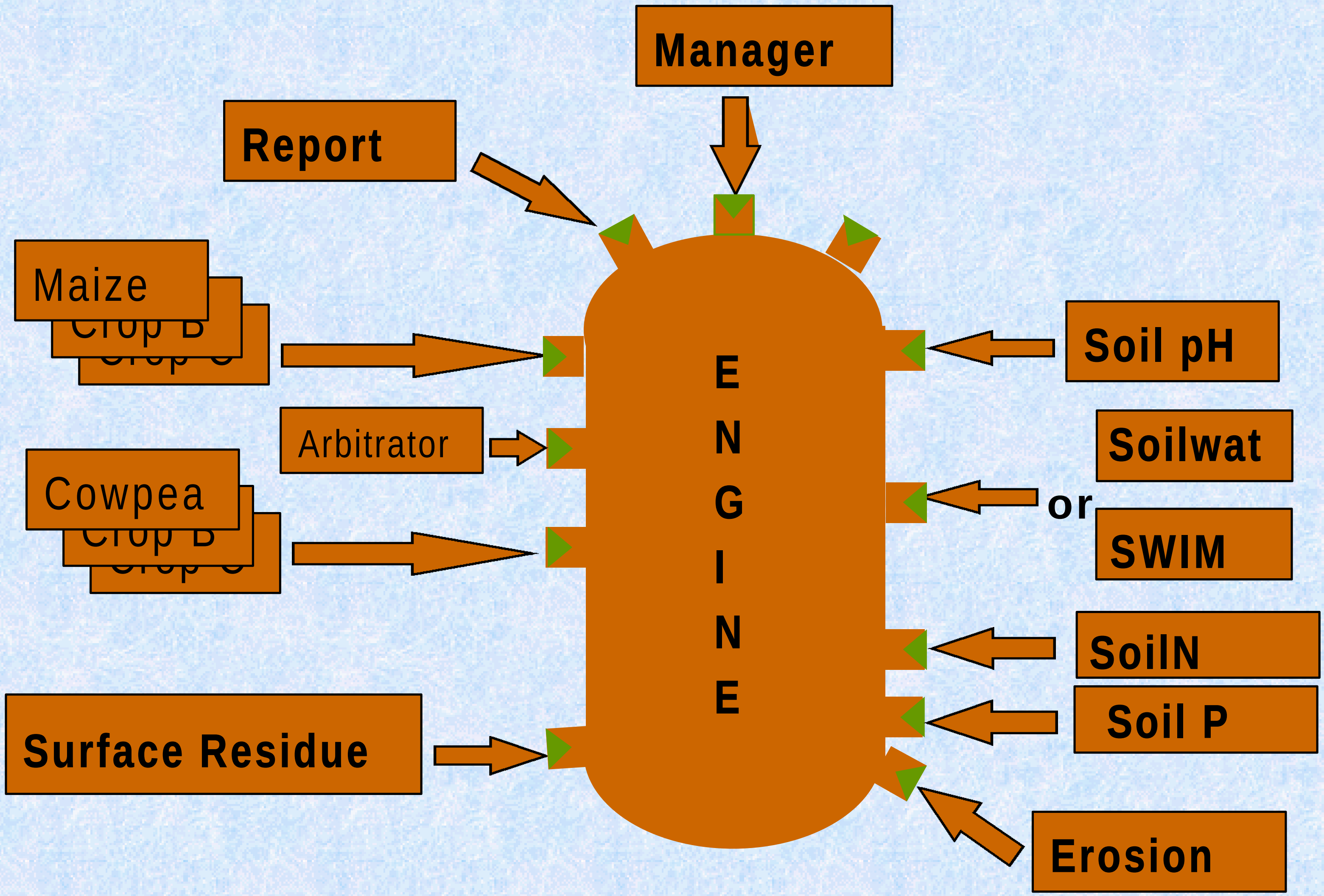

Georgia Variety Trials
Observed Data
Variety Yield (kg/ha)
4500
4000
3500
3000
2500
2000
1500
1000
500
500
1000
1500
2000
2500
3000
3500
4000
5-site Yield Average (kg/ha)
Hutcheson= 1.0914x - 145.15
Bryan = 0.8733x + 309.44
Hutcheson
Bryan

Model-Based DSS Tools

Many are never accepted, used - Why?

- Process (failure to include users from the start)
- Ownership (N.I.H. principle)
- Impractical data requirements
- Wrong problem or inadequate scope
- Cost vs. benefit
- Naïve developers
- Naïve funding agencies

APSIM - *Plug-in / Pull-out* modularity



From Brian Keating, 2000