Smart farming: using technology to improve efficiency of production

- Background on smart farming
- BlightPro decision support system (DSS)
- Future projects:
  - Opportunities for other decision tools
  - Variable rate irrigation and peanut disease project
  - Precision ag – translating data into action
  - High-throughput phenotyping
- Extension and precision ag/smart farming
The modern farm – data and connectivity

No endorsement of products or services is implied or intended.
“Precision agriculture, or ‘smart farming’, aims to optimize the yield per unit of farm land by using the most modern means in a continuously sustainable way, to achieve best in terms of quality, quantity and financial return”
SMART FARMING

- Sensing Technologies
- Data analytics Solutions
- Software Applications
- Hardware and Software Systems
- Communications Systems - e.g. Cellular
- Telematics, Positioning Technologies
No endorsement of products or services is implied or intended.
Cultivar resistance?  
- Lineage specificity

Influence of prevailing weather?

Pathogen characteristics?  
- Aggressiveness  
- Host specificity  
- Mefenoxam resistance

Pesticide use?  
- Efficacy  
- Economics  
- Environmental impact

Late blight management strategy
No endorsement of products or services is implied or intended.
Development of BlightPro Decision Support System

- Location-specific weather data
- Disease forecasting tools
- Late blight disease simulator
- Alert system
Development of BlightPro

- **BlightPro DSS for late blight** *
  - Web-based system
  - Real-time (in season) use
  - Tool for disease management, research and extension

* Small, et al. 2015 Computers and Electronics in Agriculture
Research objective

- Evaluate BlightPro DSS informed fungicide schedules relative to calendar-based schedules *
  - Disease suppression
  - Fungicide use efficiency

- Two approaches:
  - Field testing
  - Computer simulation

* Small, et al. 2015, Phytopathology
Field evaluation of late blight DSS (2010 – 2015)

**Experiment in 2010**
Katahdin (moderately susceptible)
Kennebec (moderately resistant)
Weekly sprays vs DSS (Simcast)

**National field evaluations 2014/15**
FL, MD, NC, ND, NY, PA, WA, WI
Field evaluation of late blight DSS

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Katahdin</th>
<th>Kennebec</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 day schedule</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>DSS</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Unsprayed control</td>
<td>8</td>
<td>5</td>
</tr>
</tbody>
</table>

Each error bar is constructed using 1 standard error from the mean.

Standard grower practice (seven-day interval) – 8 applications
DSS schedule Katahdin (moderately susceptible) – 6 applications
DSS schedule Kennebec (moderately resistant cultivar) – 5 applications

$P \leq 0.05$
Simulation using LATEBLIGHT 2004 model

**Mod. susceptible cultivar**

- Percent Disease obtained with actual Weather
- Percent Disease obtained with Forecast

**Mod. resistant cultivar**

- Percent Disease obtained with actual Weather
- Percent Disease obtained with Forecast

Emergence: 7/25  Inoculation: 9/11
micro-colonies 17.85

Emergence: 7/25  Inoculation: 9/11
micro-colonies 34.84

Cultivar:
- Katahdin
- Kennabec

Disease severity (%)

Treatment:
- DAS
- Untreated control

**Note:** The graph and data provided illustrate the simulation results using the LATEBLIGHT 2004 model for disease progression in different cultivars under various conditions.
Evaluation of the DSS via computer simulation *

- Historic weather data from 59 locations in 6 potato growing states (MA, ME, NC, ND, NY, WI)
  - 2000 to 2013
  - National Weather Service data - Northeast Regional Climate Center

- DSS schedule, weekly schedule, unsprayed scenarios
  - Disease severity (AUDPC)
  - Fungicide use efficiency

* Small et al 2015 Phytopathology
Evaluation of the DSS via computer simulation

- **LATEBLIGHT** model * used to simulate disease epidemic for all schedules on each resistance category for each season

- **Equivalent of 770 field exp’ts**
  - 6930 simulations

Simulated disease progress - epidemic 6 days after 18 SV

Cultivar resistance to late blight

Area under disease progress curve (%)

- Susceptible
- Moderately susceptible
- Moderately resistant

Schedule
- Unsprayed
- Calendar-based
- DSS
Fungicide use efficiency (FUE)

FUE = \left[ \frac{\text{Disease suppression due to treatment}}{\text{# sprays}} \right] \times 100

Each error bar is constructed using 1 standard error from the mean.
Simulated disease progress – randomized epidemic start

More realistic – random start date between 18 severity values and end of season
Economic value of DSS recommendations

- Collaboration with agricultural economists
  - Yangxuan Liu and Michael Langemeier from Purdue University

- Risk adjusted value of DSS calculated for two scenarios:
  - 1) Worst-case – late blight starts at 18 severity values
  - 2) Random start – late blight starts at random date in season after 18 severity values
Economic value of DSS recommendations

- Late blight starts 6 days after 18 severity values
  
  DSS generates premiums from **$50 to $544 per acre**, relative to weekly fungicide schedule

  Varies due to risk aversion level and cultivar resistance

- Late blight starts at random date in season after 18 severity values
  
  DSS generates premiums from **$30 to $86 per acre**, relative to weekly fungicide schedule

  Varies due to risk aversion level and cultivar resistance
Future work

- Evaluation in Florida

- Recommendations for fixed interval, variable dose/type of fungicide
Future research directions
Tools for peanut agronomic management

Welcome to PeanutFARM – Field Agronomic Resource Manager. PeanutFARM is a group of tools aimed at helping growers manage peanut development and maturity by tracking adjusted growing degree days (aGDD). aGDD’s use upper and lower daily air temperatures, plus the amount of water the crop receives from rainfall and irrigation, to predict the development of the crop.

In addition to tracking peanut maturity, aGDD’s are used by PeanutFARM to help schedule irrigation through estimating crop canopy cover and daily water use. This daily water use is then modified using weather data – which can be automatically drawn from state networks or input for individual fields, depending on grower preference. As the grower develops their own profile, each field can be managed separately and processed by PeanutFARM to accurately predict the need for irrigation and optimum harvest time. The purpose of PeanutFARM is to provide

PEANUT RX 2016

In 2015, losses to tomato spotted wilt across the Southeastern production region stabilized and were similar to estimated losses from 2014 at three percent, although it was more severe in some fields than in others.

Growers can achieve excellent management of this disease, and other important diseases, using Peanut Rx. This disease risk index can help growers to better understand how careful selection of production practices can reduce the risk to disease losses.

The 2016 version of PEANUT Rx has been fully reviewed and updated by the authors based upon data and observations from the 2015 field season.

Updates For 2016

Most of the changes to Peanut Rx 2016 from the previous year’s version can be found in the cultivar/variety section of Peanut Rx with new varieties added.

With additional data, risk points for leaf spot assigned to variety Georgia-12Y have been reduced from 20 to 15. Such a change indicates that Georgia-12Y has leaf spot resistance similar to that of Bailey, Tifguard and TURRanfr™727.

Three new varieties have been added to the 2016 version of Peanut Rx, all having high-oleic oil chemistry. These varieties include TURRunfr™297, Georgia-13M and Georgia-14N. In addition to having high-oleic oil chemistry, Georgia-14N is notable for its very high resistance to the peanut root-knot nematode.

Peanut Rx 2016 also includes new discussions on the impact of irrigation on management of white mold and on steps to reduce the risk of loss to the peanut root-knot nematode. As in the previous versions, growers will note that attention to variety selection, planting date, plant population, good crop rotation, tillage and other factors, will have a tremendous impact on the potential for diseases in a field.
Opportunity for peanut disease decision support system?

- Location-specific weather data
- Disease forecasting tools
- Peanut disease simulator
- Alert system
Relationship between irrigation and peanut diseases

Irrigation And White Mold

Irrigation is a critical component. However, the water applied to a crop with irrigation is also beneficial for the fungal pathogens that cause common diseases such as leaf spot, Rhizoctonia limb rot and white mold.

For white mold in particular, irrigation or ample rainfall can create conditions such as more abundant moisture for growth and also greater humidity within a canopy which favors growth and spread of white mold. However, rainfall and/or irrigation are essential in the movement of foliar-applied fungicides from the leaves to the limbs and the crown of the plant where protection is needed from white mold.

Under non-irrigated conditions, growers may actually observe more white mold than for irrigated peanuts because effective fungicides are not “washed” to the parts of the plant that must be protected from this disease.

Strategies to improve efficacy of fungicides for management of white mold in non-irrigated fields include the following:

1. Apply fungicides for control of soilborne diseases *ahead of anticipated rain events* to facilitate movement of fungicides into the crown on the plant.
2. Apply fungicides for control of soilborne diseases *at night when the leaves are folded;* such application timing will increase coverage of limbs and crowns.
Collaborative research project

- Project to investigate the relationship between variable rate irrigation and peanut diseases
  - Define irrigation management zones
  - Deploy soil moisture sensors
  - Irrigation scheduling e.g. PeanutFarm, soil moisture sensors, check book methods
  - Monitoring of canopy microclimate and disease progress

- Funded by the National Peanut Board

- Goal: collaborate with extension and farmers to design and implement project
  - Integrated research and extension project
  - Demonstration opportunities
Current level of adoption of precision Ag technology in FL

- A couple of my experiences so far…

Precision air drill planter

Cotton picker
We need to create value from farm data

“we are drowning in information, but we are starved for knowledge” - John Naisbitt, 1982

I like data and statistics

Opportunity to create algorithms that will use farm data to help inform management decisions
North Florida case study
Soil Electrical Conductivity (EC)
Soil samples - pHw
Lime recommendation
Soil samples – Phosphorus (P)
Soil samples – Potassium (K)
Soil samples – Calcium (Ca)
Soil samples – Magnesium (Mg)
Corn yield map 2015
Data layers
Data layers used to determine 2016 corn seed population
Additional data layers
Additional data layers
Additional data layers – plant population counts
Verification of actual plant population after planting

SLANTRANGE analytics detect, classify, and count corn plants after emergence in a Nebraska field.

Corn Population Density at V2
Smart crop protection

Smart crop management:
• Variable application algorithms for N. Florida:
• Crop protection (weeds, pests, pathogens)
• Integrating:
  • Plant disease epidemiology
  • Cropping history + environment + crop phenotyping
  • Predictive systems

http://www.precisionag.com/computing/software/the-new-agverdict-is-in/
Translating information into action

http://www.precisionag.com/computing/software/the-new-agverdict-is-in/
Commercial precision application technology

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Translating information into action

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Opportunity to integrate technology with sustainable systems

Sod System: (CBBP)  Conventional Rotation: (PCCP)

Oat/rye  ryegrass  oat/rye

Cotton  Bahia  Peanut  Cotton

Strip till was used in each year with best management practices. The sod based rotation rotates perennial grass through row crop land. Livestock adds flexibility and is a risk management practice during times of low prices.

+ Precision Ag Technology
High-throughput phenotyping

- **Using sensors (cameras) to capture data**
  - Assessment of plant traits
  - Monitoring crop development over time
  - Disease, weed, and pest detection/quantification
  - Monitoring disease development over time

- **Useful for many applications:**
  - Plant breeding (e.g. Brassica carinata)
  - Measuring impacts of agronomic practices
  - Measuring impacts of environment
  - Disease assessment over space and time
    - Peanut leaf spot, Sclerotinia stem rot
    - Cotton target spot and hardlock
On Bayer’s Hypercare Farms, scientists use high-precision monitoring tools to observe which crop efficiency products positively influence test plants. Ultimately, this testing can lead to improved wheat varieties and even higher yields.

It’s a bright summer day in Sabin, Minnesota. The blue sky perfectly contrasts the 62 hectare golden wheat field and the brown soil underneath it. Not far away, a tractor-like machine is visible, and a steady vibration is audible. As this machine comes closer, it becomes clear that it isn’t a normal tractor: Its front and back are equipped with several high-tech, exotic-looking attachments. That vibration sound is not merely the engine, but something else is at work.

221

million hectares of wheat are grown each year worldwide. This equals the area of Greenland.
Source: Bayer

This multi-functional machine is called PhenoTracker. In contrast to standard machines, it has high-precision monitoring attachments that help scientists to determine the condition of the crops.
Extension and precision ag/smart farming

- Precision/Smart Ag market is very competitive and many tools and new types of equipment are being released

- Farmers are skeptical of recommendations from companies that also sell inputs/equipment e.g. seed/crop protection product

- As a public sector scientist and educator you can play an important role as a source of information

- There will be a growing need for training and support

- What is the current status of precision ag in Florida?
  - Survey to collect data about current use of technology
Efficiency is not only about yield and profit...

It’s not all about money…

It’s also about time and environmental impact
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