Economic Analysis of Using Cornell Decision Support System for Tomato Production

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Introduction

- World's second largest producer of tomatoes: US

- Late blight infection is a persistent problem
  - Contagious
  - Easily dispersed

Late blight symptoms on tomato, Image from usablight.org

Introduction

- Fungicide application can be used to manage late blight
  - Fungicide spray on a regular calendar basis (7-Day)
  - Cornell Potato/Tomato Late Blight Decision Support System (DSS)

- Objective
  - Examine the economic impact of using DSS to mitigate the impact of late blight

Data

Computer Simulated Data:

- By Ian Small and Laura Joseph from Fry Lab at Cornell University

- DSS and 7-day spray schedule in 12 locations (NC) from 2000 to 2013
  - <u>No. of applications</u>
  - <u>Disease severity</u>

- 3 levels of cultivar resistance (Susceptible, Moderately Susceptible, Moderately Resistant)

Data

Net Income over Fungicide Cost/Acre

- *Net income over fungicide cost = Tomato price ∗ average tomato yield − (Fungicide cost + application cost) ∗ number of application*

Budget Data

- Annual tomato prices and average tomato yields from 2000-2009
  - USDA Tomato Statistics for fresh tomatoes
- Bravo WeatherStik fungicide price ($8.63/acre/application)
  - By Dr. M. T. McGrath in April 2013
- Ground fungicide application cost ($6.58/acre/application)
  - Lazarus (2013)
- USDA Prices Paid Indices

Summary of Statistics

Susceptible Cultivar			N = 112	/Acre
Data Source	Variable	Schedule	Mean	Std Dev
Ian Small and Laura Joseph (Fry Lab)	No. of Applications*	7-day	11.00	0.00
		DSS	12.6	2.6
	Disease Severity: RAUDPC***	7-day	0.1023	0.1210
		DSS	0.0048	0.0165
Yangxuan Liu (AgEcon Purdue)	Cost of Fungicide Applications*	7-day	$ 124.02	13.25
		DSS	$ 141.56	29.30
	Net Income over fungicide cost	7-day	$ 9,230.62	658.81
		DSS	$ 9,213.08	656.82

* , **, ***Mean difference is statistically significant at 1% , 5%, and 10% significant level.

Methods

- Stochastic efficiency with respect to a function
  - Hardaker et al. 2004
  - Use certainty equivalents (CE) to rank risky alternatives
  - Identify the utility weighted risk premium (RP)

Methods

- Risk premium (RP) or the value of information

  - $RP_{DSS,Calendar,R_a} = CE_{DSS,R_{a(w)}} - CE_{Calendar,R_{a(w)}}$

- Relative Risk Aversion Levels (0, 1, 3, 5)

- SIMETAR: Simulation and Econometrics to Analyze Risk

  - Richardson, Schumann and Feldman 2006

SERF: Average of Certainty Equivalent

| Risk Aversion | Spray Schedule | | Risk Premium |
	7-Day	DSS	DSS over 7-Day
r=0	$ 9,251.42	$ 9,233.73	$ (17.69)
r=1	$ 9,227.88	$ 9,210.34	$ (17.54)
r=3	$ 9,183.29	$ 9,166.06	$ (17.23)
r=5	$ 9,142.28	$ 9,125.39	$ (16.89)

Susceptible Cultivars /Acre

Note: r is the relative risk aversion coefficient. A power utility function is assumed.

Conclusion

- The value of DSS ranged from -$17.69 to $48.33 per acre.
  - The calendar spray schedule was preferred for the susceptible cultivars.
  - DSS was preferred for moderately susceptible cultivars and moderately resistant cultivars.
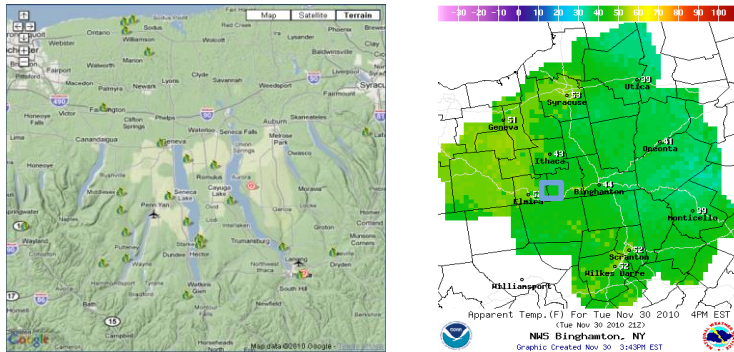
Further study

- Incorporate the relationship between disease severity and tomato yields

Questions, Comments

Appendix: DSS Components

Location-specific weather data

Disease forecasting tools

|	Simcast Summary							
Date	7/31	8/1	8/2	8/3	8/4	8/5	8/6	8/7
Blight Units	13	18	25	32	39	44	51	57
Fungicide Units	-2	-6	-10	-14	-15	-16	-17	-18

Key	
	Below Threshold
>=30	Blight Unit Threshold Exceeded and 5 Days Since Last Fungicide
<=-15	Fungicide Unit Threshold Exceeded and 5 Days Since Last Fungicide

Late blight disease simulator

Report Name: 3   Report Date: 11/22/2010 Simulation: 7/21
Cultivar: ALL BLUE; Resistance: susceptible; Maturity: late.
Weather source: Arkport lat. 42.42 lon. −77.70 elev. 1200
Forecast source: arkportfarm lat. 42.40 lon. −77.70 elev. 1197

Emergence: 5/11 Inoculation: 7/7
micro−colonies 176.29
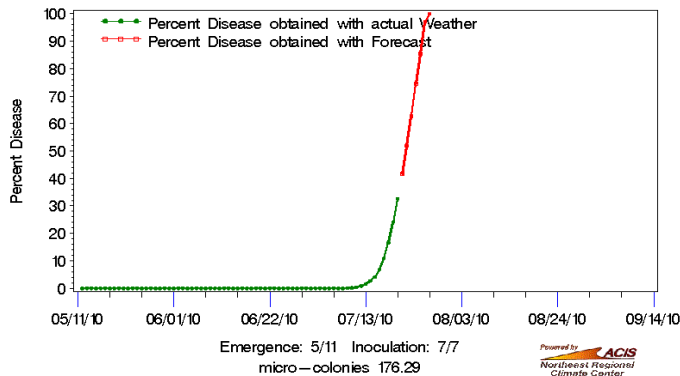
Alert system
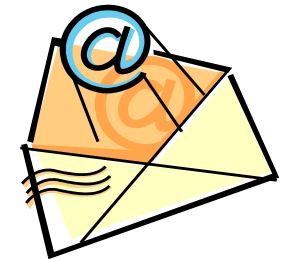
(Slide provided by Ian Small)

Appendix: Methodology

- SERF

$$EU(w, r(w)) = \int U(w, r(w))dF(w) = \sum_{i=1}^{m} U(w_i, r(w))P(w_i), r_1(w) \leq r(w) \leq r_2(w)$$

- Power utility used for stochastic efficiency with respect to a function

$$U(x) = \frac{x^{1-r}}{1-r} \text{ for } r \neq 1; U(x) = \ln(x) \text{ for } r = 1$$

- $CE(w, r(w)) = U^{-1}(w, r(w))$

- Utility weighted risk premium (RP)

$$RP_{DSS,Calendar,R_a} = CE_{DSS,R_{a(w)}} - CE_{Calendar,R_{a(w)}}$$

Summary of Statistics

Moderately Susceptible Cultivars			N = 112	/Acre
Data Source	Variable	Schedule	Mean	Std Dev
Ian Small and Laura Joseph (Fry Lab)	No. of Applications*	7-day	11.00	0.00
		DSS	8.8	1.9
	Disease Severity: RAUDPC	7-day	0.00734	0.0445
		DSS	0.00340	0.0160
Yangxuan Liu (AgEcon Purdue)	Cost of Fungicide Applications*	7-day	$ 124.02	13.25
		DSS	$ 98.72	21.5
	Net Income over fungicide cost	7-day	$ 9,230.62	658.81
		DSS	$ 9,255.92	658.8

* , **, ***Mean difference is statistically significant at 1% , 5%, and 10% significant level.

Summary of Statistics

Moderately Resistant Cultivars			N = 112	/Acre
Data Source	Variable	Schedule	Mean	Std Dev
Ian Small and Laura Joseph (Fry Lab)	No. of Applications*	7-day	11.00	0.00
		DSS	6.8	1.4
	Disease Severity: RAUDPC	7-day	0.000654	0.00491
		DSS	0.000216	0.00071
Yangxuan Liu (AgEcon Purdue)	Cost of Fungicide Applications*	7-day	$ 124.02	13.25
		DSS	$ 76.00	16.4
	Net Income over fungicide cost	7-day	$ 9,230.62	658.81
		DSS	$ 9,278.64	660.74

* , **, ***Mean difference is statistically significant at 1% , 5%, and 10% significant level.

SERF: Average of Certainty Equivalent

	Spray Schedule		Risk Premium
Risk Aversion	7-Day	DSS	DSS over 7-Day
r=0	$ 9,251.42	$ 9,276.88	$ 25.46
r=1	$ 9,227.88	$ 9,253.42	$ 25.54
r=3	$ 9,183.29	$ 9,209.02	$ 25.73
r=5	$ 9,142.28	$ 9,168.23	$ 25.95

Moderately Susceptible Cultivars/Acre

Note: r is the relative risk aversion coefficient. A power utility function is assumed.

SERF: Average of Certainty Equivalent

	Spray Schedule		Risk Premium
Risk Aversion	7-Day	DSS	DSS over 7-Day
r=0	$ 9,251.42	$ 9,299.51	$ 48.09
r=1	$ 9,227.88	$ 9,276.00	$ 48.12
r=3	$ 9,183.29	$ 9,231.50	$ 48.21
r=5	$ 9,142.28	$ 9,190.61	$ 48.33

Moderately Resistant Cultivars/Acre

Note: r is the relative risk aversion coefficient. A power utility function is assumed.