# Plant Disease Update

James Woodhall
University of Idaho, Parma

# Talk outline

- Diagnosis
- Predictive diagnosis
- Fungicide resistance update
- Key finds from 2018

# Parma diagnostic lab

- U of I ‘Diagnostic Hub’
- Nematology and Entomology labs on site
- Part of a plant pathology research program
- NPDN Lab
- Also setting up lab in Idaho Falls
- Recruiting two specialist diagnosticians

NPDN
National Plant Diagnostic Network

# Lab services

- General diagnosis
- Isolation
- Baiting, incubation and glasshouse tests
- Antibody test kits
- DNA barcoding
- LAMP
- PCR and qPCR – soil, plant material, water, air

# Molecular diagnostics lab at Parma

- 2016 refurbishment
- 2 Kingfishers
- 4 real-time PCR machines
- Segregated labs
  - Enhanced workflow
  - Reduce contamination
- Up to 300 DNA samples a day

# Diagnostic terms

- You **diagnose** a disease from an infected plant
- You **detect** a pathogen in material such as seeds, soil and water
- You **identify** a species from a pure culture/specimen

- '**Predictive diagnosis**' is detecting the pathogen prior to symptoms developing at key stages in crop production

# Why do diagnosis?

- Preventative or corrective action
- Horizon scanning/intelligence

  Species/strain level – long term surveillance for population changes

  Why bother?

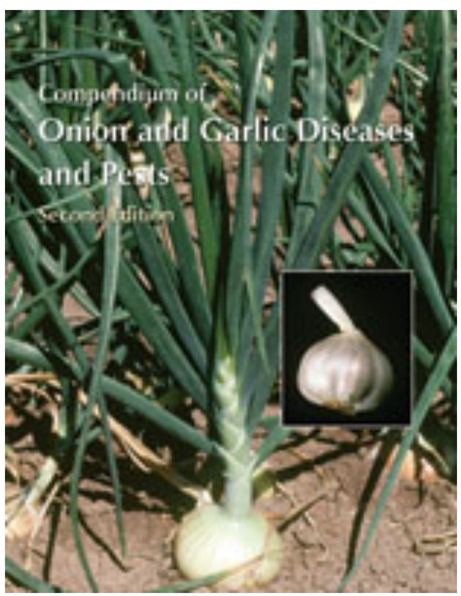
  - Fungicide sensitivity
  - Plant resistance
  - Environmental extremes
  - Inform crop rotations

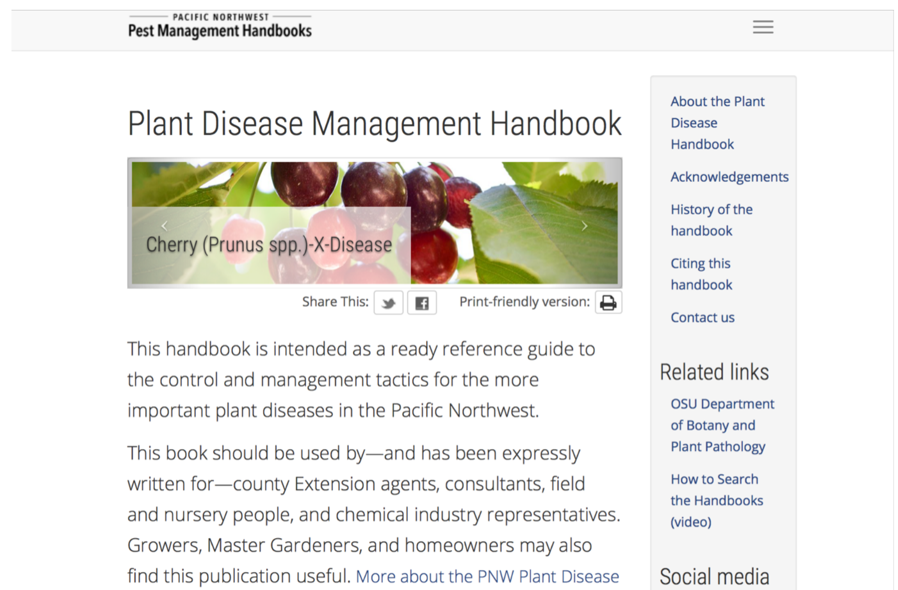
# When to use a diagnostic service?

- Anything that looks unhealthy
- Existing diseases you may know well – but more aggressive
- Usual controls methods failing
- Quality check on your own diagnostic skills

# Sources of help for diagnosis

- Consultants
- University Plant Clinics
- Extension/Research Specialist
- University Plant Diagnostic Labs
- ISDA



# Diagnostic tools - ‘testing’

- Visual/microscopic examination
- Incubate to force symptoms/microbe growth
- Isolation
- Antibody based methods
- Molecular methods
    - PCR (Real-time PCR, qPCR, TaqMan etc)
    - Isothermal methods (LAMP & RPA)
    - DNA sequencing ‘basic’
    - Next generation sequencing

# Key considerations for ‘testing’

- Appropriate sample

  **Dying not dead, range of material**

  **We isolate from the ‘interface’**

  **Phone before sending and send sample information too**

# Testing is not always definitive...

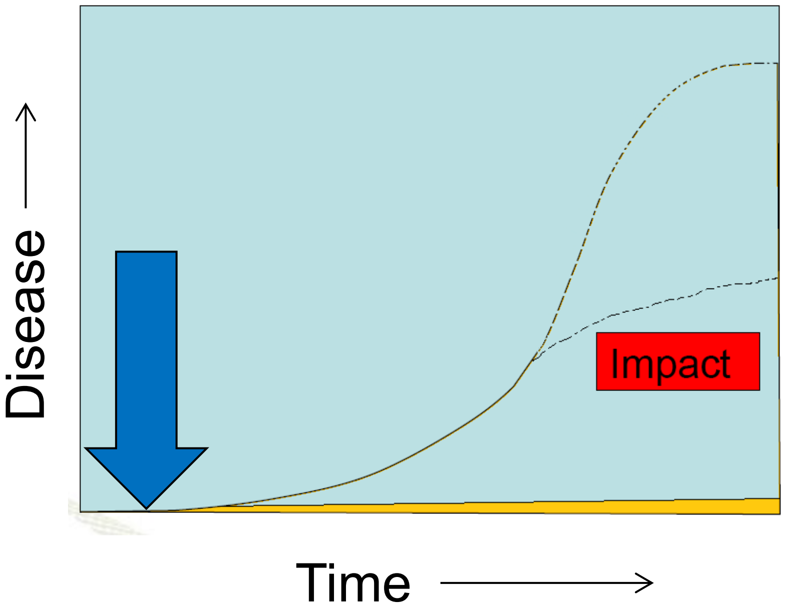
- Appropriate interpretation of the test
  - Not detected not always means disease free
  - Detection does not always indicate cause

- Combination of tests, field history, weather conditions, symptoms + <u>experience</u>

  =>diagnosis

# Predictive diagnostics?

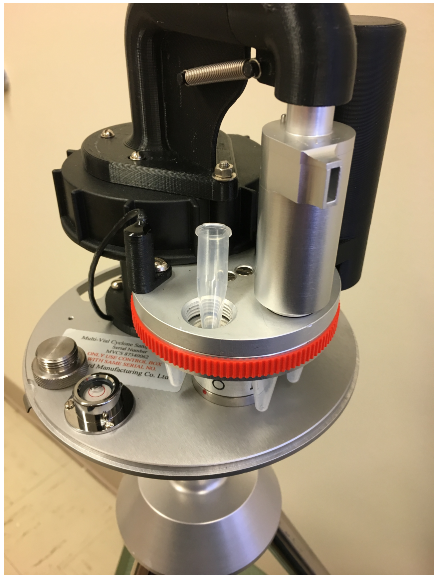
- **‘Reactive diagnostics’**
- Identify causal agent
- Correct rectifying treatment
- Disease Intelligence




- **‘Predictive diagnostics’**
- Precision agriculture
- Planting decisions
- Reduce pesticide inputs & losses

# Predictive diagnostics - air

- Spore sampling
- Daily automatic sampling for 8 days
- Samples 16.5 liters/minute
- Test vials by qPCR
- Alerts 24 -48 h after samples received



# 2019 network

- Integration of weather data
- U of I and Agrimet stations
- Risk by zone
- Website for current and archive data:

**CropAlerts.org**

Future work – integrate with fungicide resistance?

# Mixtures better than alternations?

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Analytical and Theoretical Plant Pathology

*e*-Xtra*

## Using Epidemiological Principles to Explain Fungicide Resistance Management Tactics: Why do Mixtures Outperform Alternations?

James A. D. Elderfield, Francisco J. Lopez-Ruiz, Frank van den Bosch, and Nik J. Cunniffe†

First and fourth authors: Department of Plant Sciences, University of Cambridge, Cambridge, CB2 3EA, United Kingdom; second author: Curtin University, Centre for Crop and Disease Management, Department of Environment and Agriculture, Bentley, WA 6845, Australia; and third author: Rothamsted Research, Harpenden, AL5 2JQ, United Kingdom.

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**ABSTRACT**

Whether fungicide resistance management is optimized by spraying chemicals with different modes of action as a mixture (i.e., simultaneously) or in alternation (i.e., sequentially) has been studied by experimenters and modelers for decades. However, results have been inconclusive. We use previously parameterized and validated mathematical models of wheat Septoria leaf blotch and grapevine powdery mildew to test which tactic provides better resistance management, using the total yield before resistance causes disease control to become economically ineffective ("lifetime yield") to measure effectiveness. We focus on tactics involving the combination of a low-risk and a high-risk fungicide, and the case in which resistance to the high-risk chemical is complete (i.e., in which there is no partial resistance). Lifetime yield is then optimized by spraying as much low-risk fungicide as is permitted, combined with slightly more high-risk fungicide than needed for acceptable initial disease control, applying these fungicides as a mixture. That mixture rather than alternation gives better performance is invariant to model parameterization and structure, as well as the pathosystem in question. However, if comparison focuses on other metrics, e.g., lifetime yield at full label dose, either mixture or alternation can be optimal. Our work shows how epidemiological principles can explain the evolution of fungicide resistance, and also highlights a theoretical framework to address the question of whether mixture or alternation provides better resistance management. It also demonstrates that precisely how spray tactics are compared must be given careful consideration.

Designing long-lasting, effective tactics to control plant disease remains a key challenge (Cunniffe et al. 2015). Fungicide resistance management—optimizing deployment to delay emergence or spread of resistant pathogen strains—has been studied for decades (Russell 2005). Many tactics have been proposed. For a single fungicide, resistance management can be based on the method of application, changing the dose (van den Bosch et al. 2011), the timing (van den Berg et al. 2013), whether treatment is applied to the leaves or on the seed (Kitchen et al. 2016), the spatial pattern of spraying (Parnell et al. 2006), or the number of sprays per season (van den Berg et al. 2016). However, for disease control as well as resistance management, fungicides with different modes of action are very often combined in a spray program (van den Bosch et al. 2014b).

Significant attention has therefore been devoted to how to best combine fungicide applications. Possibilities include a mixture, spraying the two fungicides at the same time, or as an alternation, applying sequentially. The risk of resistance development varies between fungicides (Brent and Hollomon 2007). Resistance emerges to some chemicals within a few years of use, while others provide durable control for decades. We distinguish high-risk fungicides, to which resistance is already present or very likely to emerge, and low-risk fungicides, to which no significant resistance has yet been observed. We focus here on the case of mixture and alternation of a single high-risk fungicide with a single low-risk when there is a fungal strain fully resistant to the high-risk. Despite many experimental (Cooke et al. 2004; Dovas et al. 1976; Lamondia 2001; Sanders et al. 1985; Vali and Moorman 1992) and modeling (Birch and Shaw 1997; Doster et al. 1990; Hobbelen et al. 2011a, 2013; Josepovits 1989; Josepovits and Dobrovolszky 1985; Kable and Jeffery 1980; Shaw 1989a; Skylakakis 1981) studies focusing on precisely this situation, no conclusive answer has emerged to the important but very simple question: does mixture or alternation provide better resistance management?

Although previous studies have led to equivocal results, fungicide mixtures have often been found to provide superior resistance management (van den Bosch et al. 2014b). van den Bosch et al. (2014a) introduced a simple set of governing principles as a theoretical framework to synthesize these and other results concerning resistance management, formalizing previous concepts from the literature (Milgroom and Fry 1988; Staub and Sozzi 1983). These governing principles are based on constant rates of selection for resistance. We generalize this here, quantifying total selection for resistance by integrating a time-varying selection coefficient over time. The selection coefficient is defined as the difference in fitness between fungicide-sensitive and fungicide-resistant strains

$$s = r_R - r_S \quad (1)$$

where $r_R$ and $r_S$ are the per capita growth rates of the resistant and sensitive pathogen strains, respectively. The total amount of selection for resistance is then given by the cumulative selection coefficient

$$\sigma = \int_0^T s(t)\mathrm{d}t \quad (2)$$

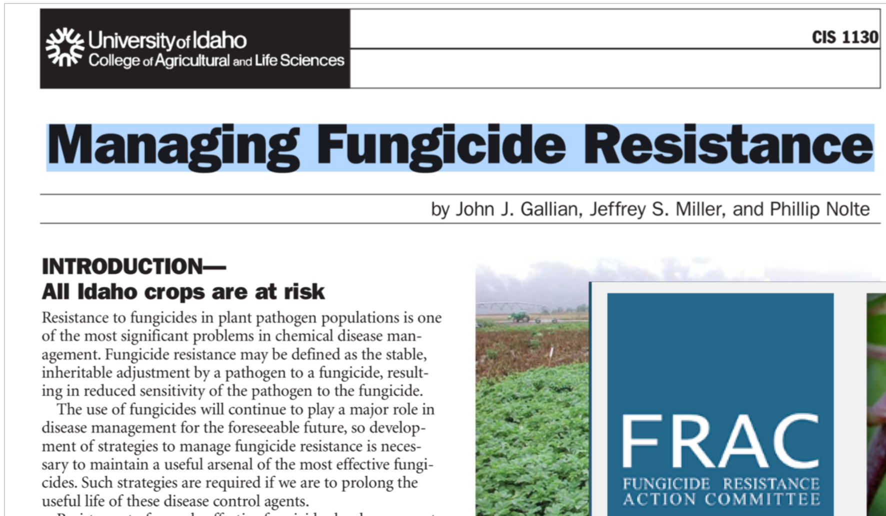
in which $T$ is the time of exposure to fungicide. Selection for resistance can therefore be reduced by decreasing both $r_R$ and $r_S$, by decreasing $r_R$ only, or by decreasing $T$ (van den Bosch et al. 2014a).

The governing principles can be applied to the comparison between mixture and alternation. Fungicide mixtures can reduce

†Corresponding author: N. J. Cunniffe; E-mail: njc1001@cam.ac.uk

*The *e*-Xtra logo stands for "electronic extra" and indicates that one supplementary figure, two supplementary tables, and one supplementary text file are published online.

# Further information



University of Idaho
College of Agricultural and Life Sciences

CIS 1130

# Managing Fungicide Resistance

by John J. Gallian, Jeffrey S. Miller, and Phillip Nolte

**INTRODUCTION—**
**All Idaho crops are at risk**

Resistance to fungicides in plant pathogen populations is one of the most significant problems in chemical disease management. Fungicide resistance may be defined as the stable, inheritable adjustment by a pathogen to a fungicide, resulting in reduced sensitivity of the pathogen to the fungicide.

The use of fungicides will continue to play a major role in disease management for the foreseeable future, so development of strategies to manage fungicide resistance is necessary to maintain a useful arsenal of the most effective fungicides. Such strategies are required if we are to prolong the useful life of these disease control agents.

Resistance to formerly effective fungicides has been report-

# White rot in *Allium* in Northern Idaho

- *Sclerotium cepivorum*
- Spread by soil-borne sclerotia (1 per kg)
- Regulated pathogen in southern Idaho

# Conclusions

- Use your diagnostic labs - samples form vital part of disease surveillance and feed into the R&D cycle
- Please sign up for receiving spore trap alerts
- Aware of fungicide resistance
- Be aware of species complexes