

# Epidemiology of Eyespot, Stripe Rust and Soilborne Wheat Mosaic

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## **Goals for Today**

**Discuss basic principles of plant disease epidemiology**

**Describe three important wheat diseases with different epidemiological characteristics**

**Discuss control options for each disease relative to their epidemiology**

**→ better understand why we do what we do to control diseases**

# Epidemiology

## **Epidemiology**

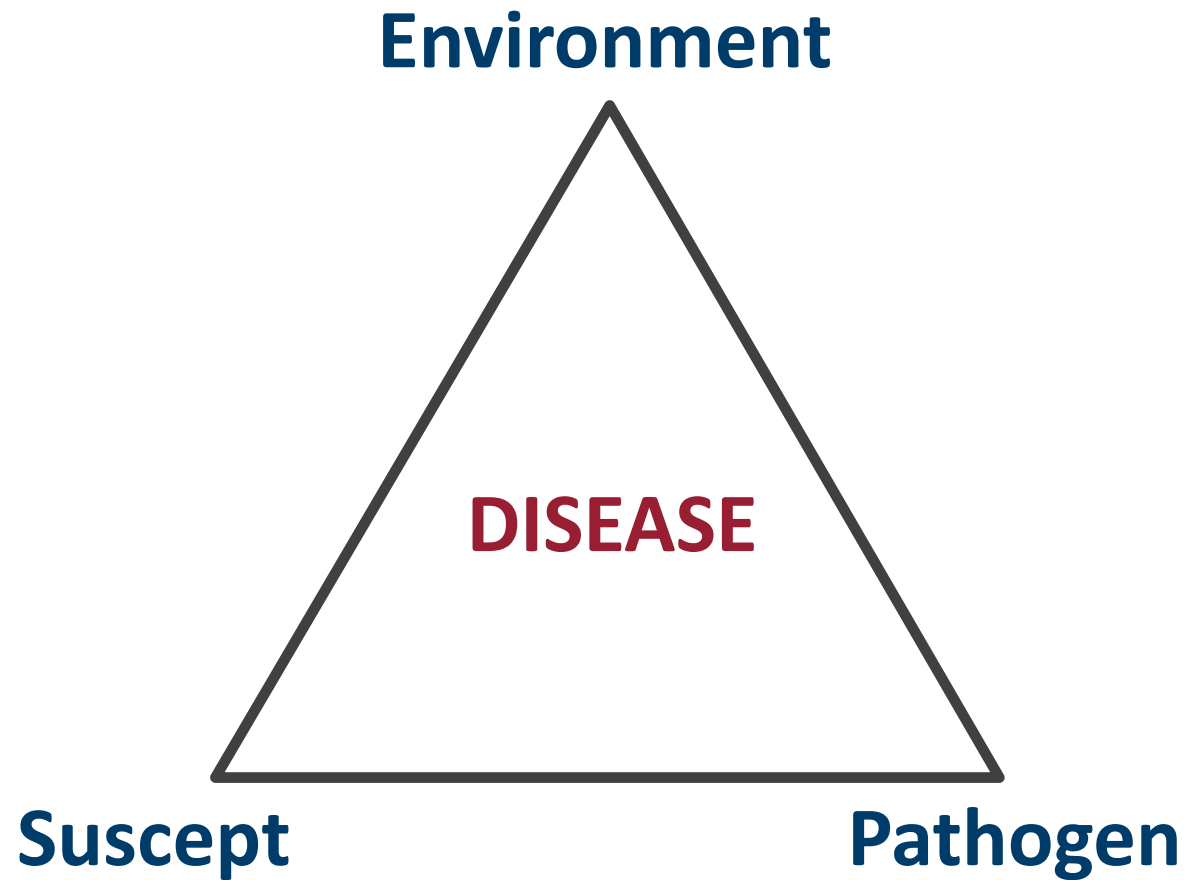
= the study of disease in populations

## **Epidemic**

= increase in disease intensity in a host population over time and space

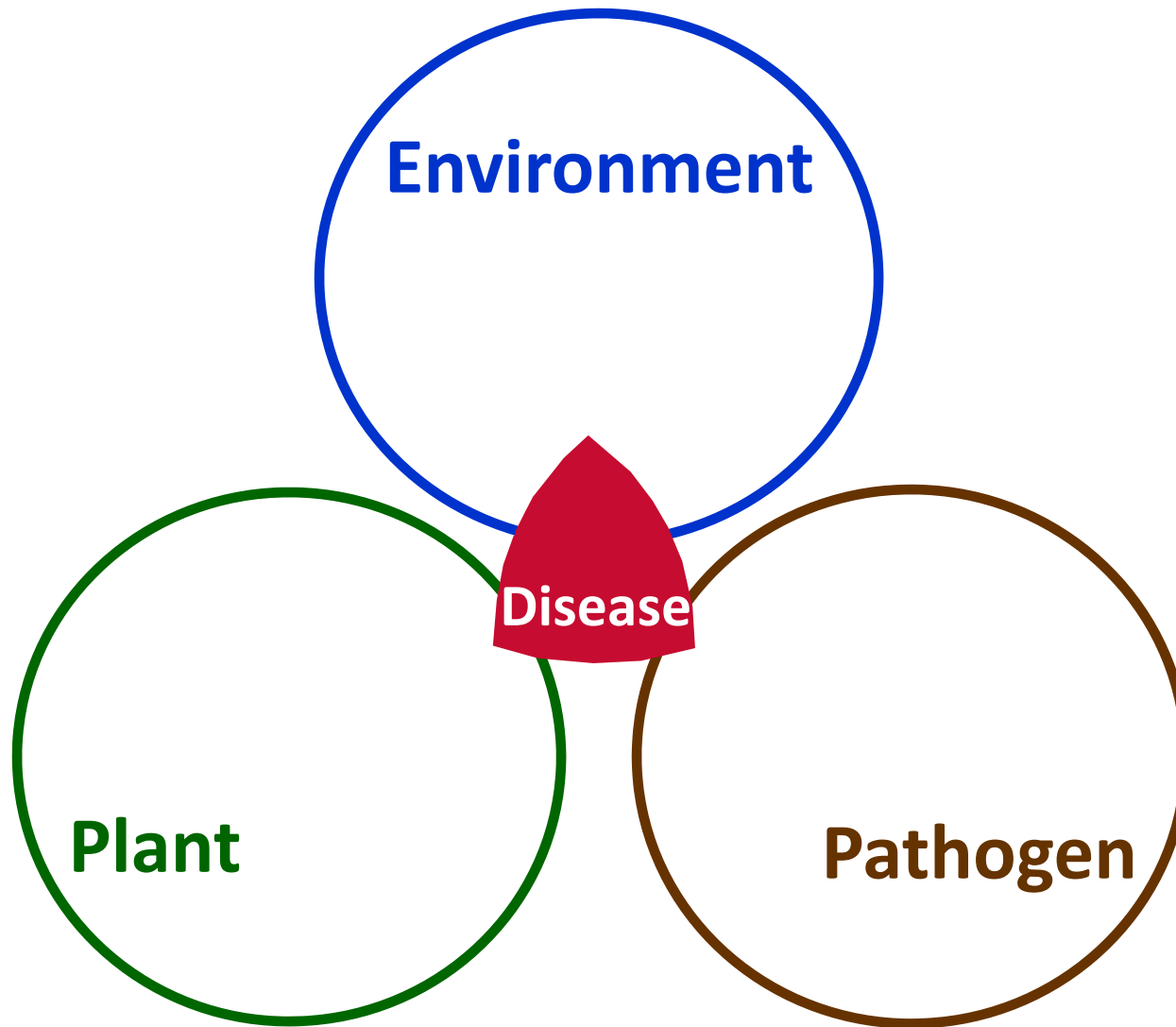
Vanderplank (1963)

# Plant Disease Triangle

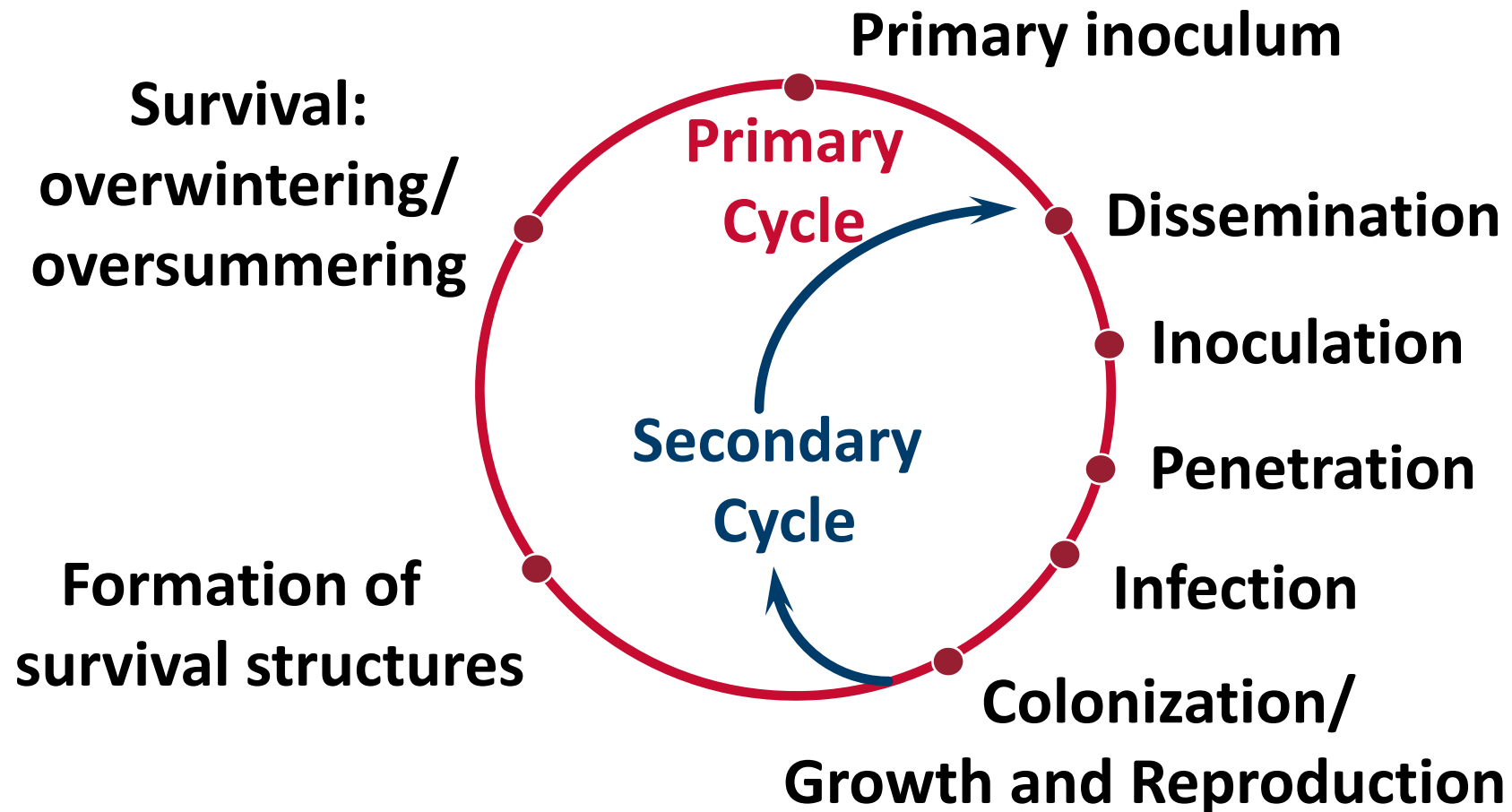




# **'Disease Triangle'**



# The Generalized Disease Cycle



# Principles of Epidemiology

## Types of disease cycles:

Single-cycle (*Monocyclic*) diseases

- primary inoculum only

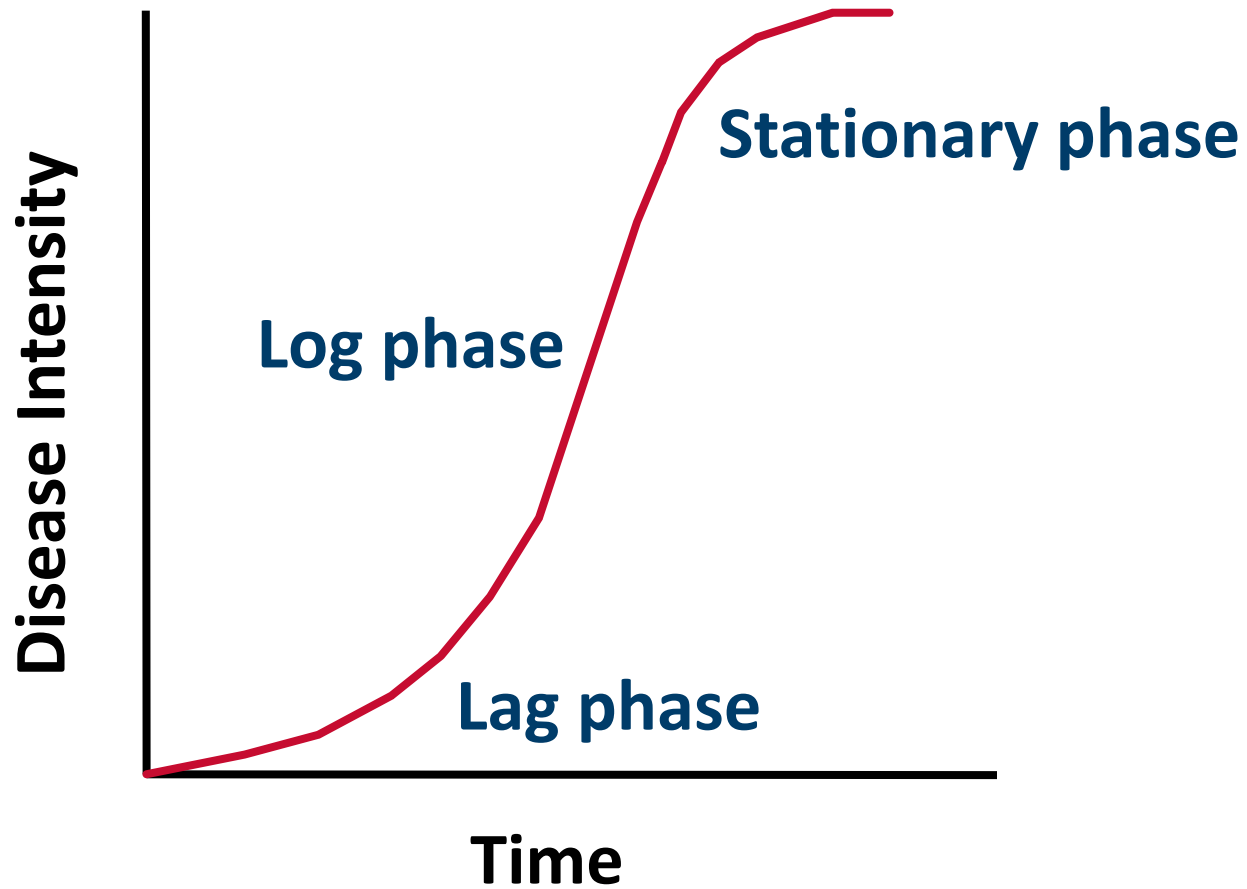
Multiple-cycle (*Polycyclic*) diseases

- primary & secondary inoculum

→ Multiple-cycle diseases have greater potential for rapid epidemic development than single-cycle diseases

# Modeling Epidemics

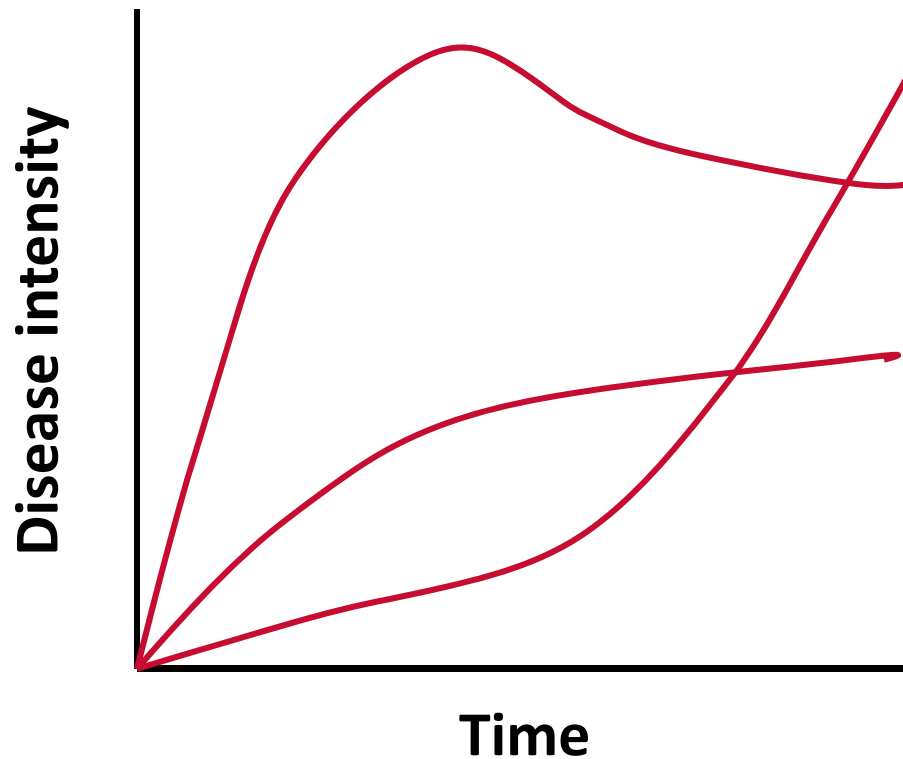
## Logistic Model



# Quantifying Disease

## Disease progress curve

= disease intensity over time

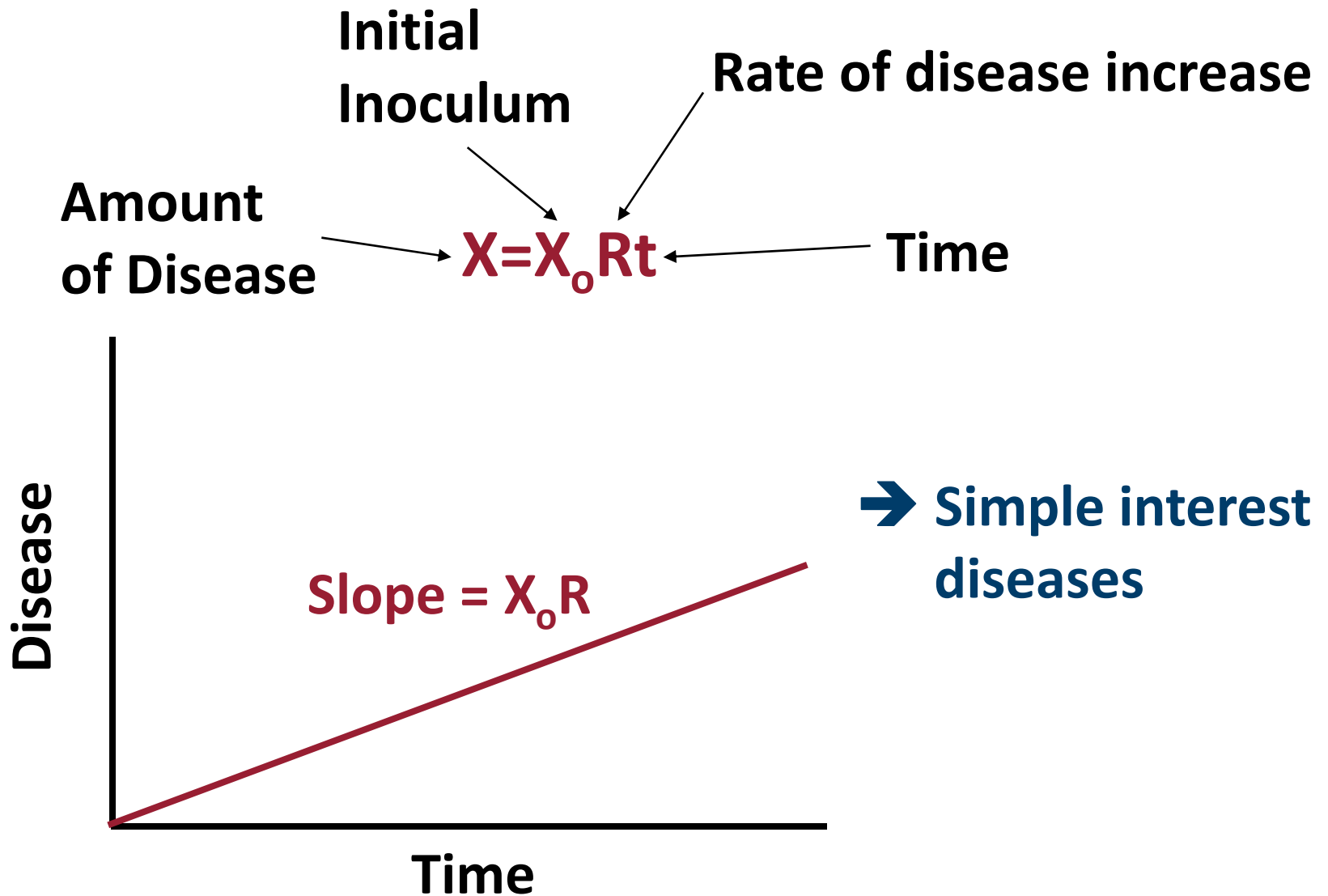


# Quantifying Disease

## Why use disease progress curves?

- Compare control measures
- Compare effect of environment on disease development
- Predict future disease development
  - ➔ Disease forecasting for improved control

# Modeling Monocyclic Epidemics



# Modeling Polycyclic Epidemics

$$X = X_0 e^{rt}$$

**X =** disease at time t

**X<sub>0</sub> =** initial inoculum

**r =** rate of disease  
increase

**t =** time

**e =** base of natural log

➔ money at time t

➔ initial investment

➔ interest rate



# Modeling Polycyclic Epidemics

Initial Inoculum

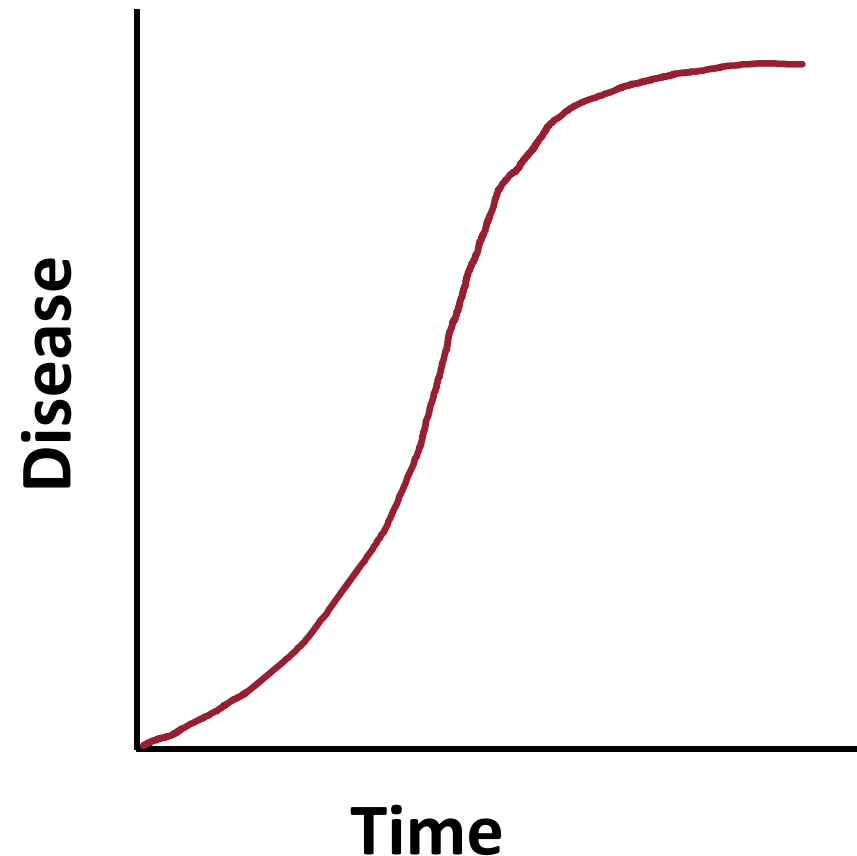
Rate of Disease Increase

$$X = X_0 e^{rt}$$

Time

Natural log

→ Compound interest diseases



## **Polyetic Epidemics**

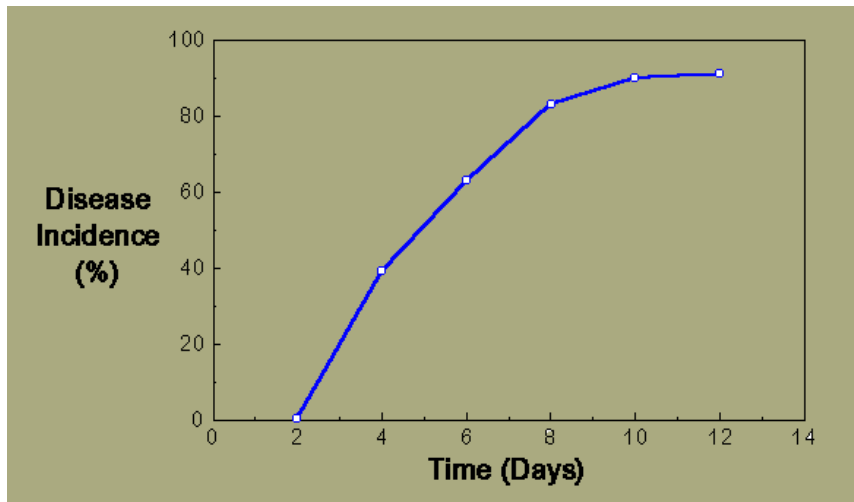
**Inoculum increases within each season and disease builds-up across years**

**→ monocyclic in one season and polycyclic across seasons**

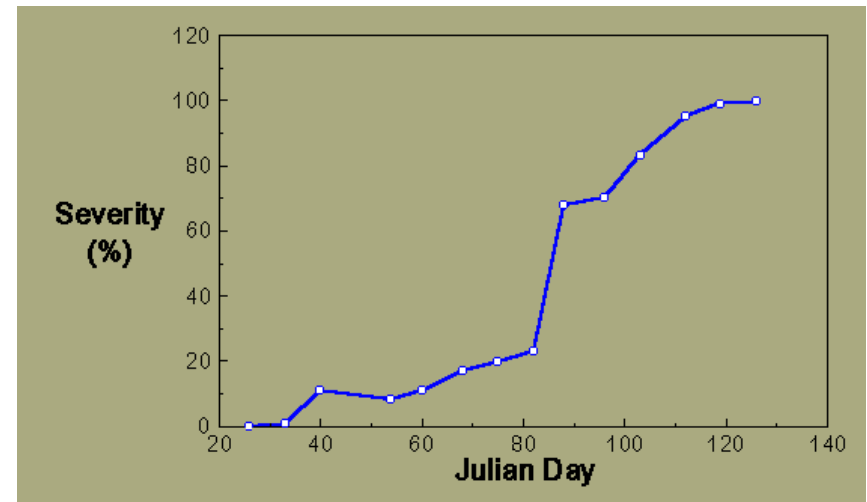
**- typical of perennial plants, but not always**

**e.g. mistletoe, Dutch elm disease**

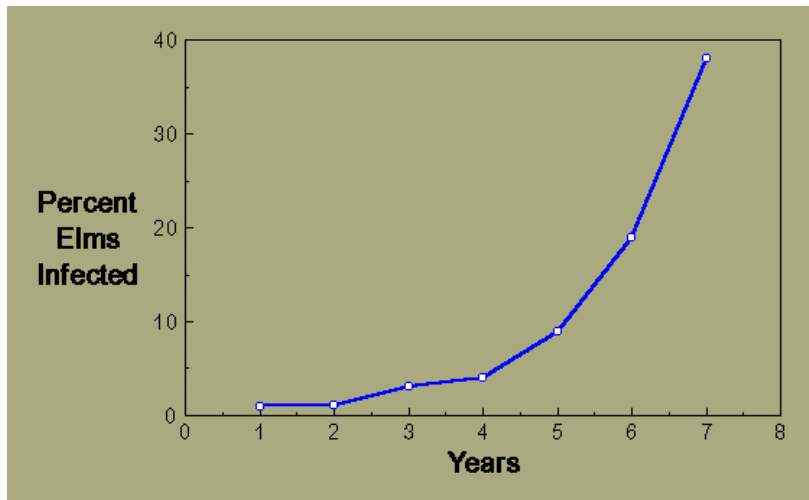
# Comparing Epidemic Types



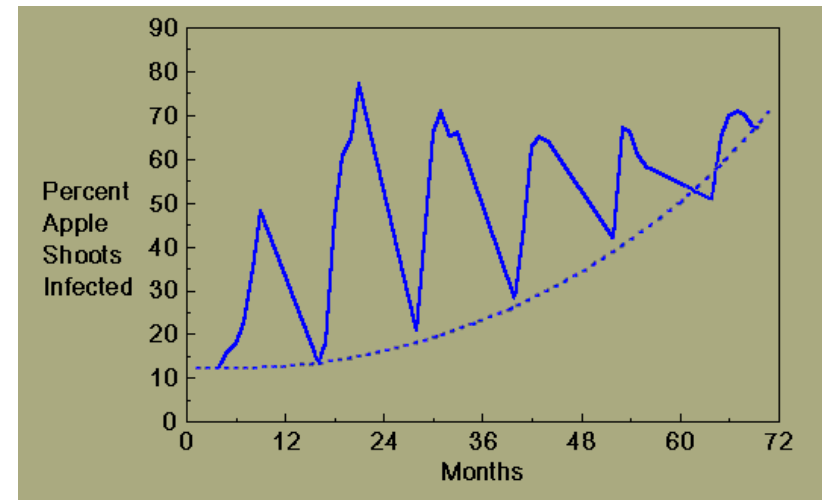
*Sclerotium rolfsii* on bean



Net blotch on barley



Dutch elm disease



Apple powdery mildew

# Managing Epidemics

**Monocyclic:**  $X = X_0 R t$

**Polycyclic:**  $X = X_0 e^{rt}$

**Two ways to reduce  $X$  (disease):**

- Reduce the initial inoculum  $X_0$
- Reduce the rate of disease development  
( $R$  or  $r$ )

# Effect of $X_0$ on Epidemic Development

$X_0$  depends upon:

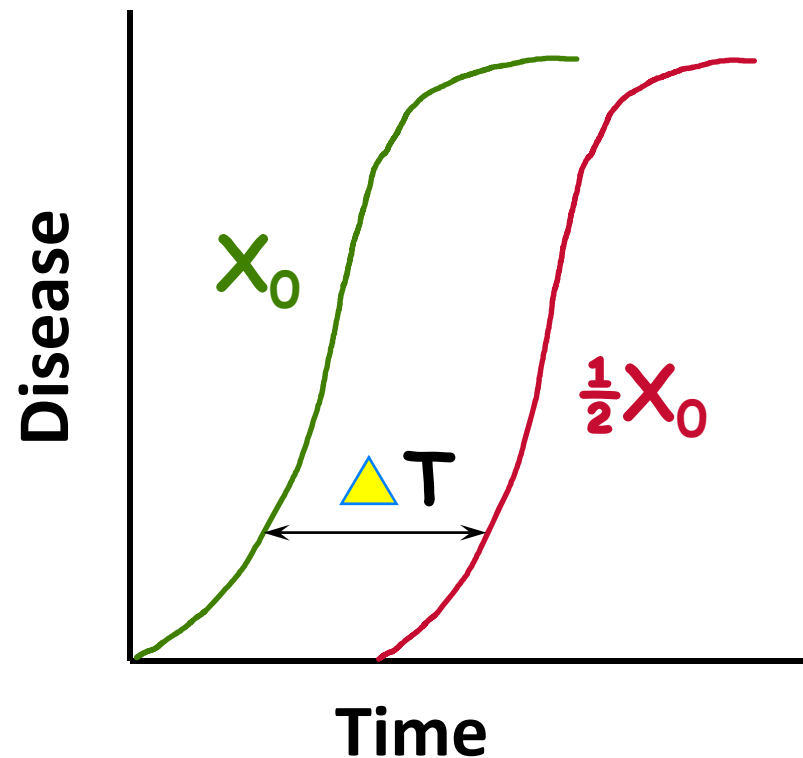
- inoculum from previous crops within a field
- inoculum from crops in adjacent fields

# Effect of $X_0$ on Epidemic Development

$X_0$  is affected by:

- destroying infested plant debris
- removing diseased plants
- chemical seed treatments
- protective fungicides
- race-specific disease resistance
- biological control agents targeted at initial inoculum

## Effect of $X_0$ on Epidemic Development



→ delay onset and reduce the duration of the epidemic

# Effect of $r$ ( $R$ ) on Epidemic Development

$r$  depends upon:

- reproductive potential of the pathogen
- virulence of the pathogen
- susceptibility of the host
- conduciveness of environment

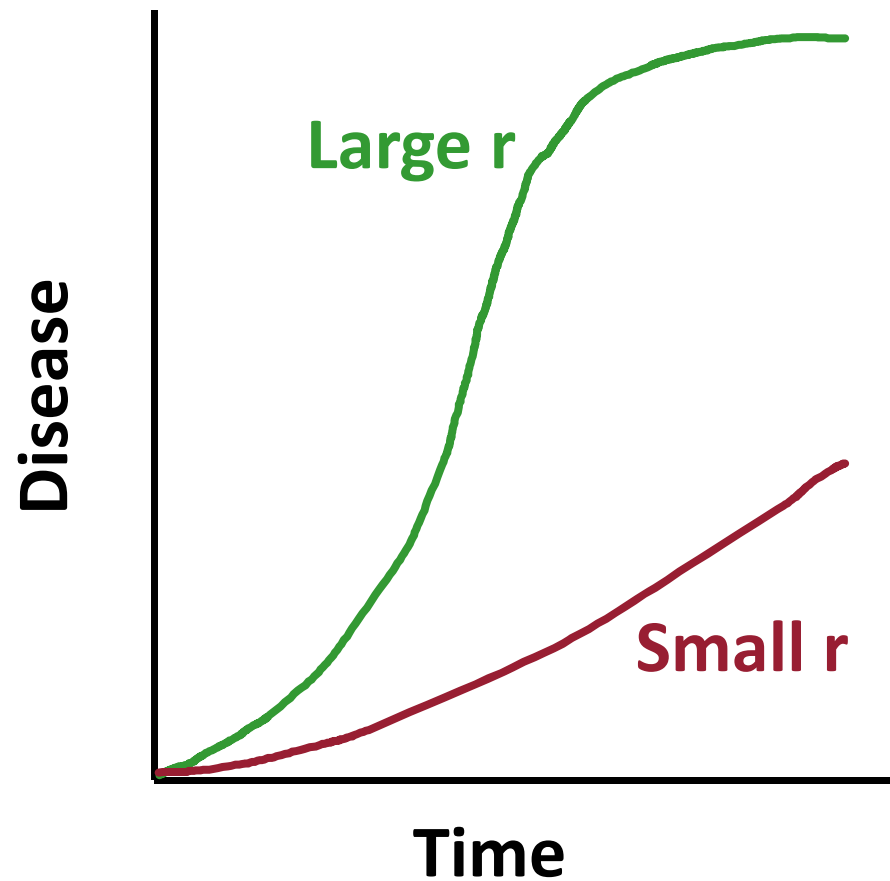


# Effect of $r$ ( $R$ ) on Epidemic Development

$r$  is affected by:

- non-specific disease resistance
- systemic fungicides
- cultural practices that alter environment
- removal of diseased plants

## Effect of $r$ on Epidemic Development

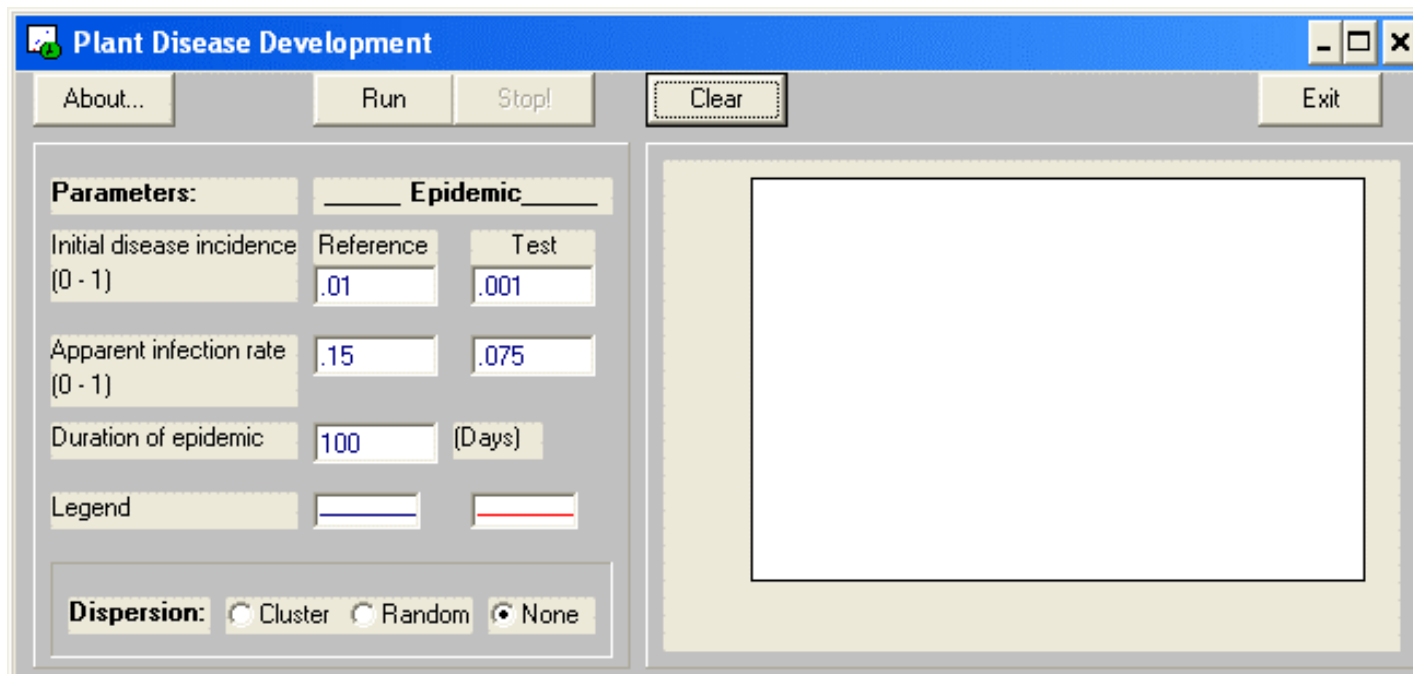


→ Slow the rate of spread of the epidemic

# Disease Simulation

## Plant Disease Development -

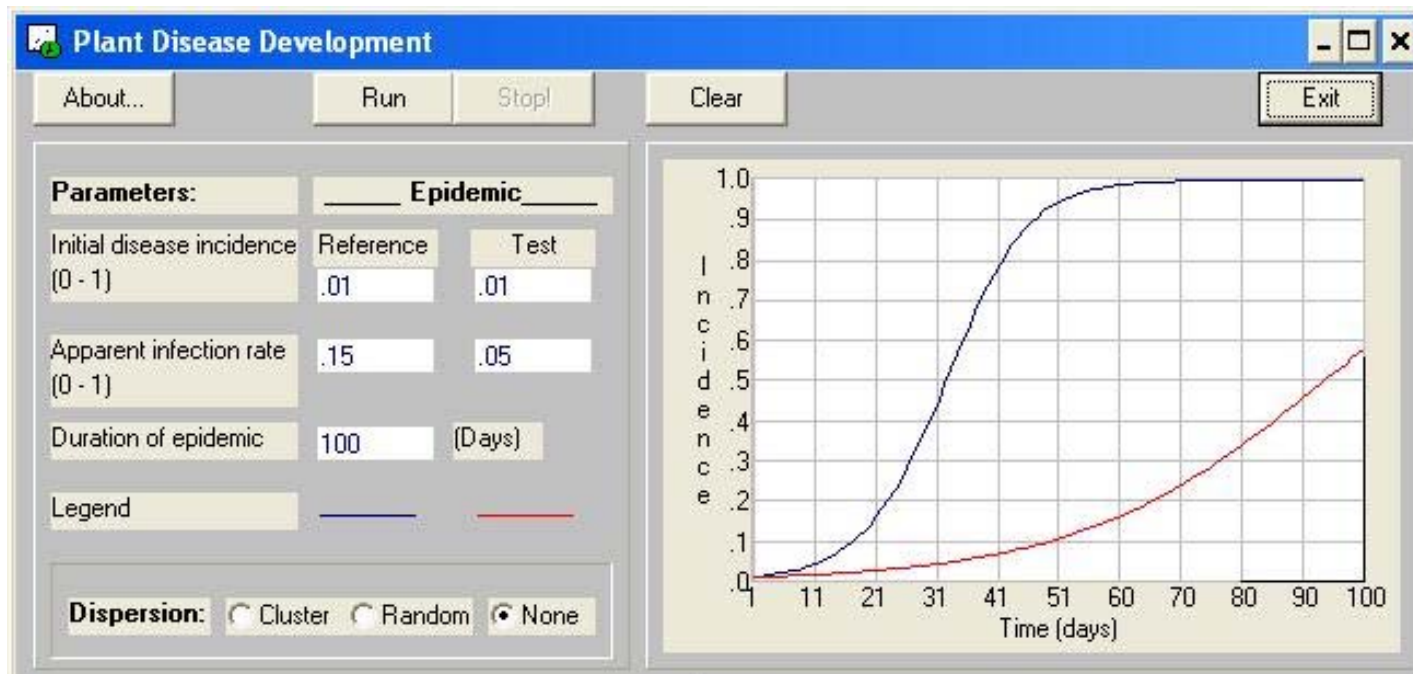
Arneson, P.A. 2001 Plant Disease Epidemiology: Temporal Aspects. *The Plant Health Instructor*. DOI: 10.1094/PHI-A-2001-0524-01 (Revised 2011)



# Disease Simulation

## Scenarios:

1. Compare the effect of **rate of disease increase,  $r$** ,  
with the same **starting inoculum,  $X_0$**   
 $r = 0.15$  (polycyclic),  $0.05$  (monocyclic)  
 $X_0 = 0.01$  (1%)



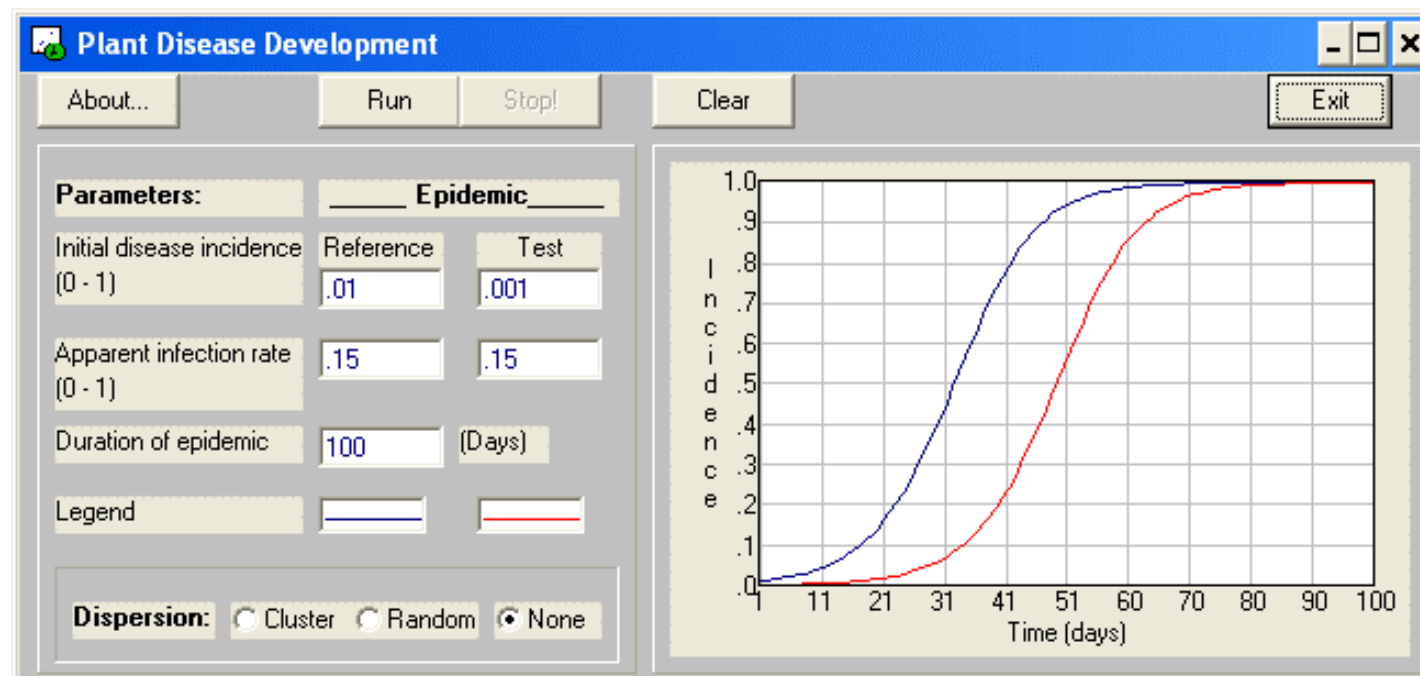
# Disease Simulation

## Scenarios:

2. Compare the effect of  $X_0$  with the same  $r$

$r = 0.15$

$X_0 = 0.01$  (1%),  $0.001$  (0.1%)



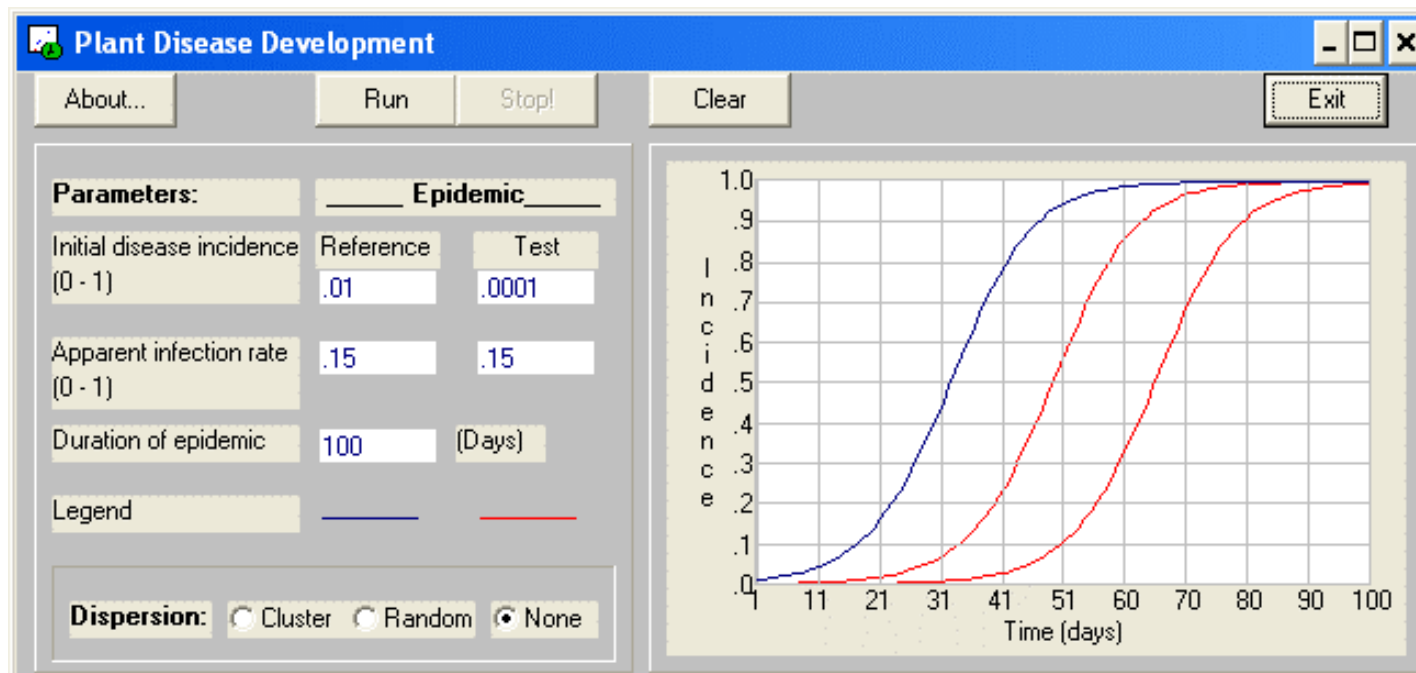
# Disease Simulation

## Scenarios:

3. Compare the effect of reducing  $X_0$  when  $r$  is high

$r = 0.15$

$X_0 = 0.01$  (1%),  $0.001$  (0.1%),  $0.0001$  (0.01%)



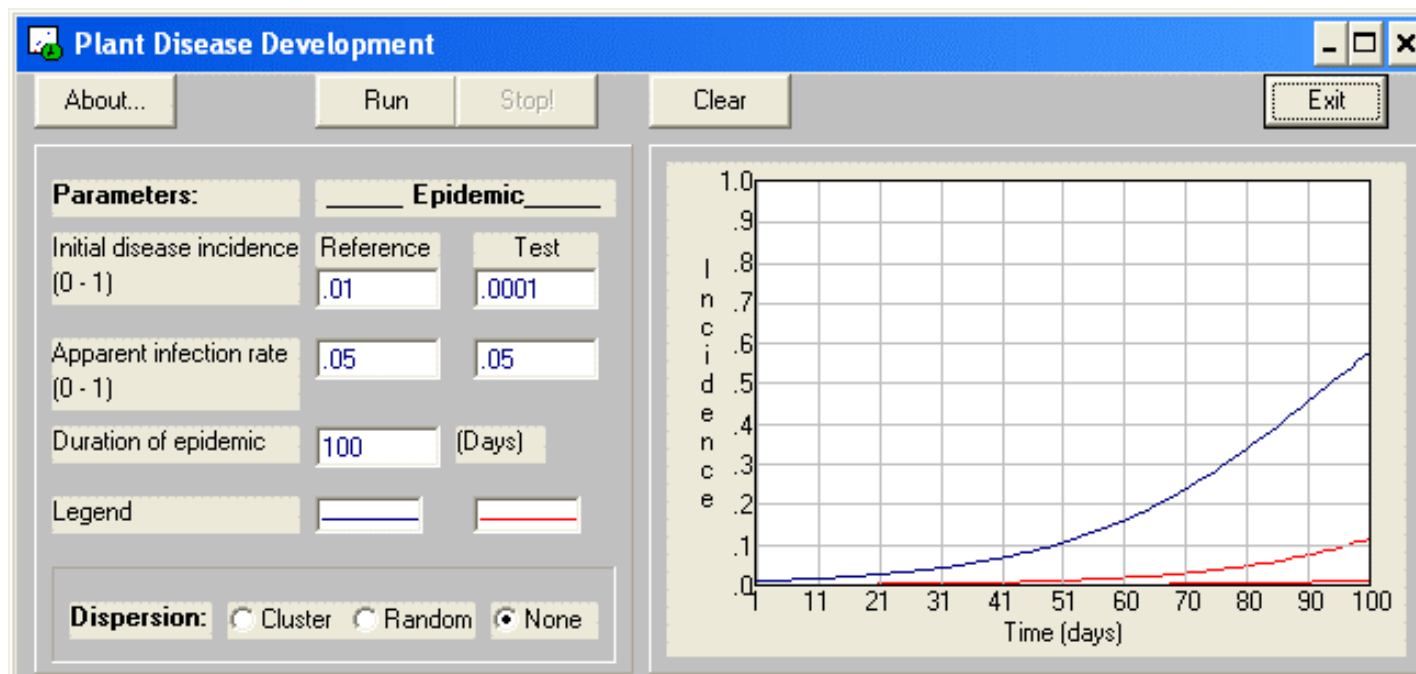
# Disease Simulation

## Scenarios:

4. Compare the effect of reducing  $X_0$  when  $r$  is low

$r = 0.05$

$X_0 = 0.01$  (1%),  $0.001$  (0.1%),  $0.0001$  (0.01%)



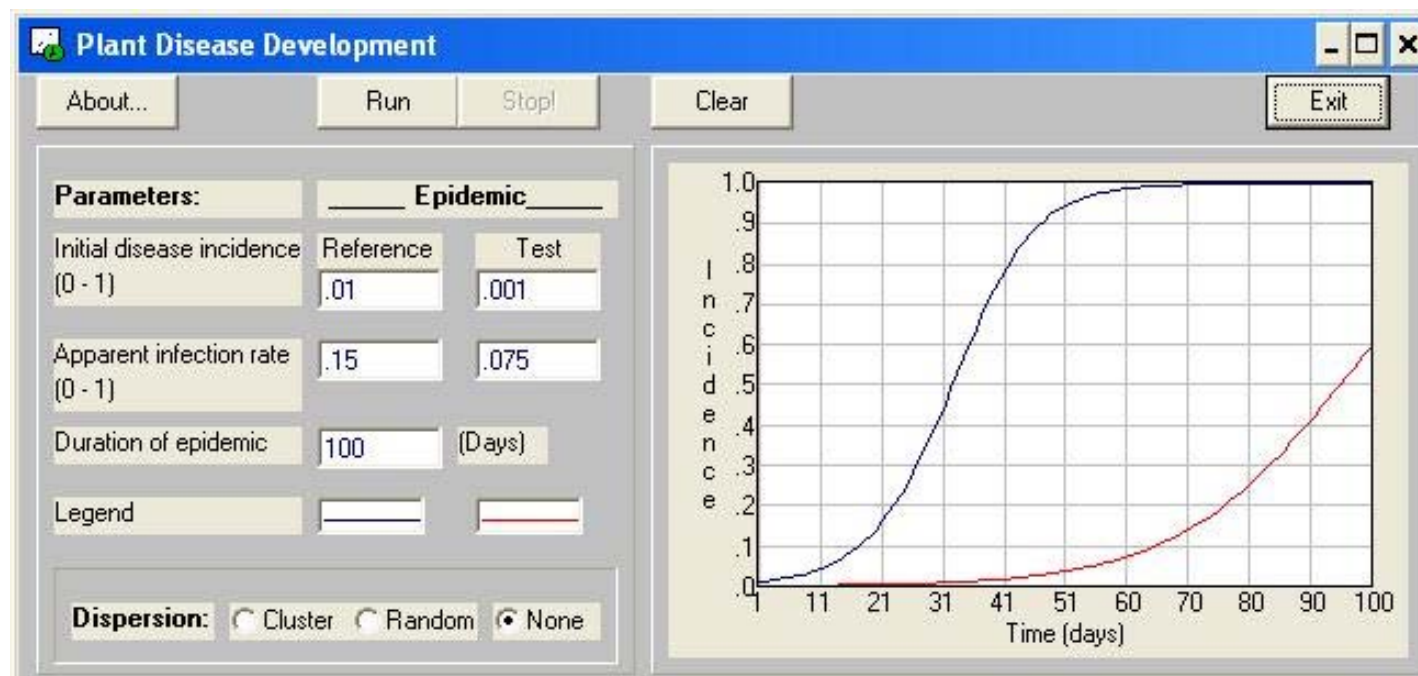
# Disease Simulation

## Scenarios:

5. Compare the effect of reducing both  $r$  and  $X_0$  for a polycyclic disease

$r = 0.15, 0.075$

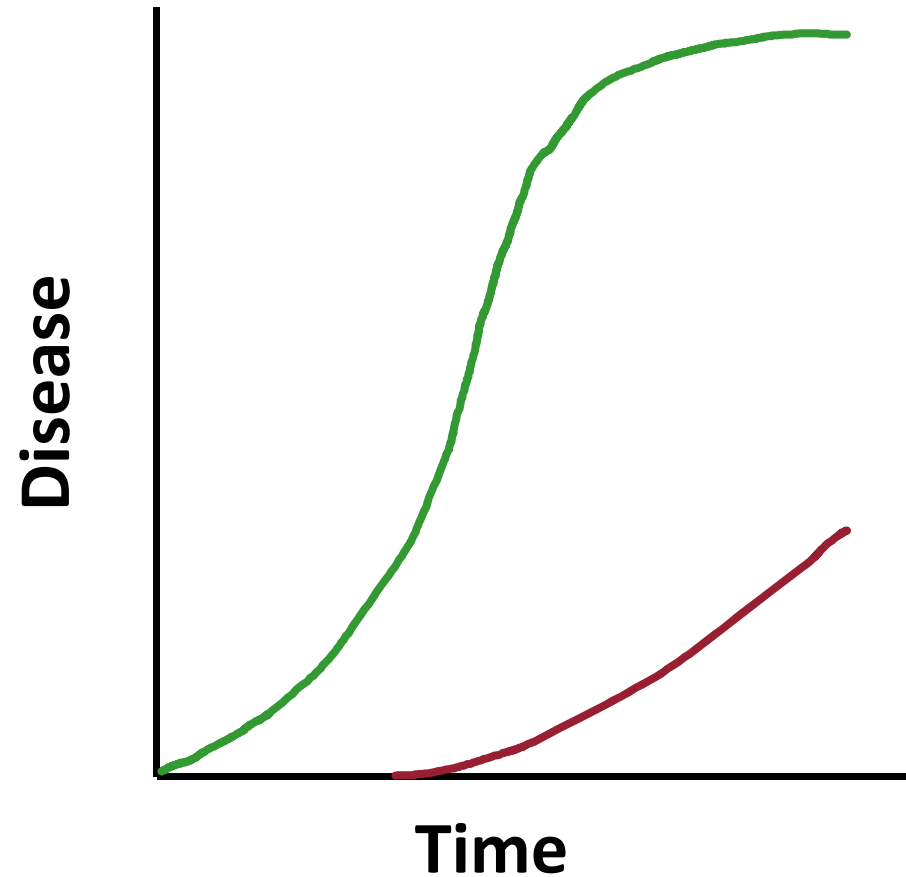
$X_0 = 0.01$  (1%),  $0.001$  (0.1%)





# Integrated Control

→ Reduce both  $X_0$  and  $r$  to delay onset (shorten the epidemic) and reduce rate of spread (less disease)



## Eyespot or Strawbreaker Foot Rot



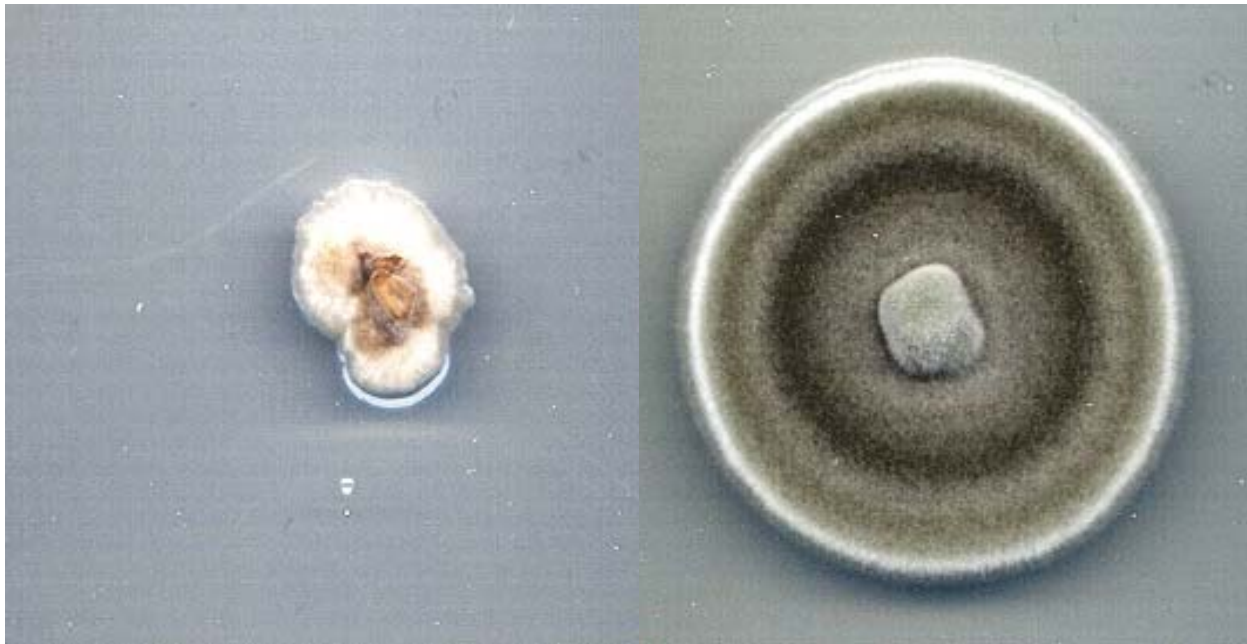
## Eyespot Lodging





## Eyespot Pathogens

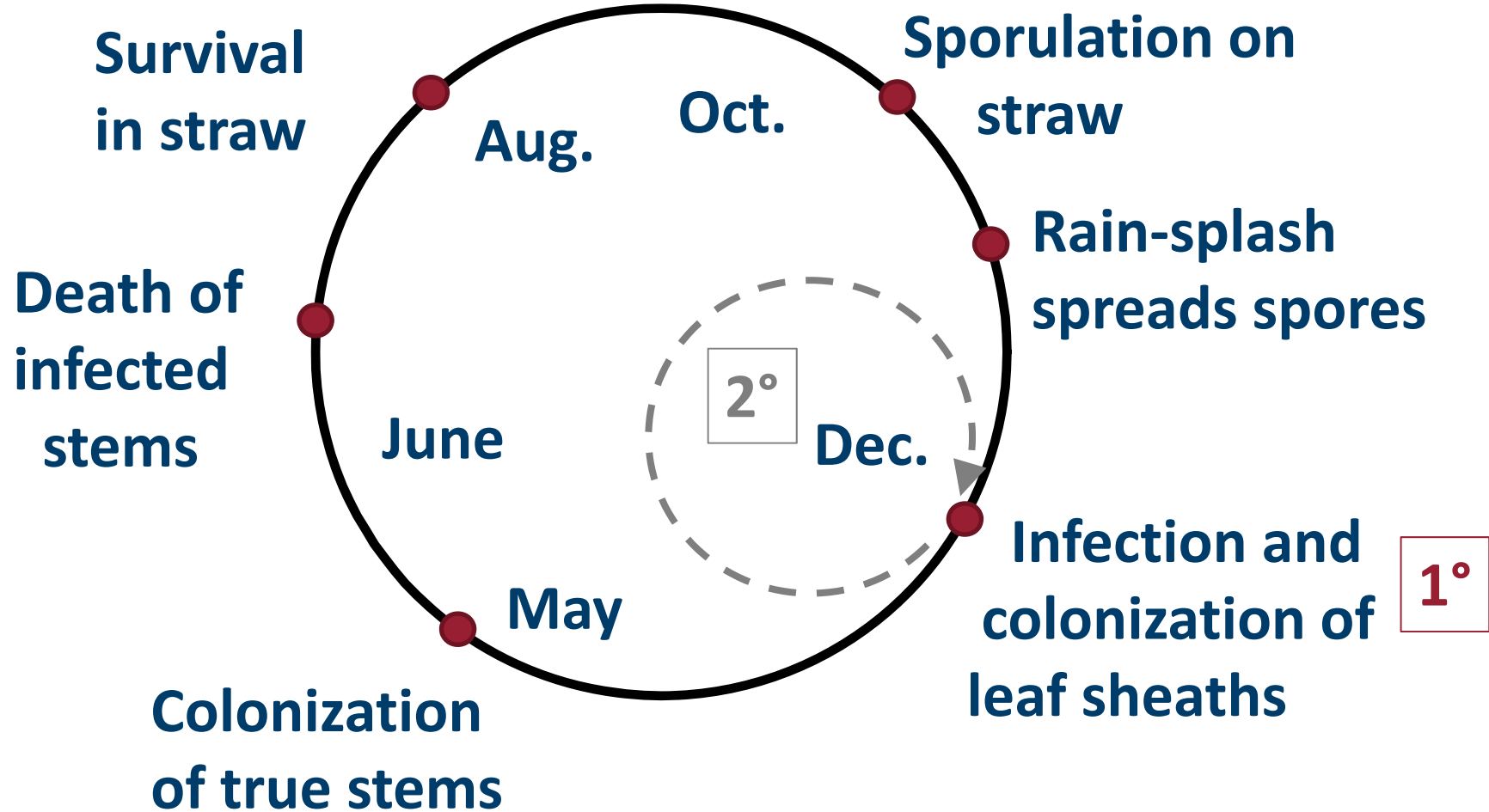
Old names = *Cercospora*,  
*Pseudocercospora*, *Tapesia* & *Oculimacula*



*O. acuformis*

*O. yallundae*

# Eyespot Disease Cycle



# **Factors Affecting Eyespot**

**Autumn temperatures**

**Rainfall**

**Snow cover**

## Stripe Rust





# Stripe Rust



Courtesy X. Chen



## The Wheat Rusts

Stripe rust (yellow rust) - cool season: 50-64°F

*Puccinia striiformis* f. sp. *tritici*

Leaf rust (brown rust) - moderate: 68-77°F

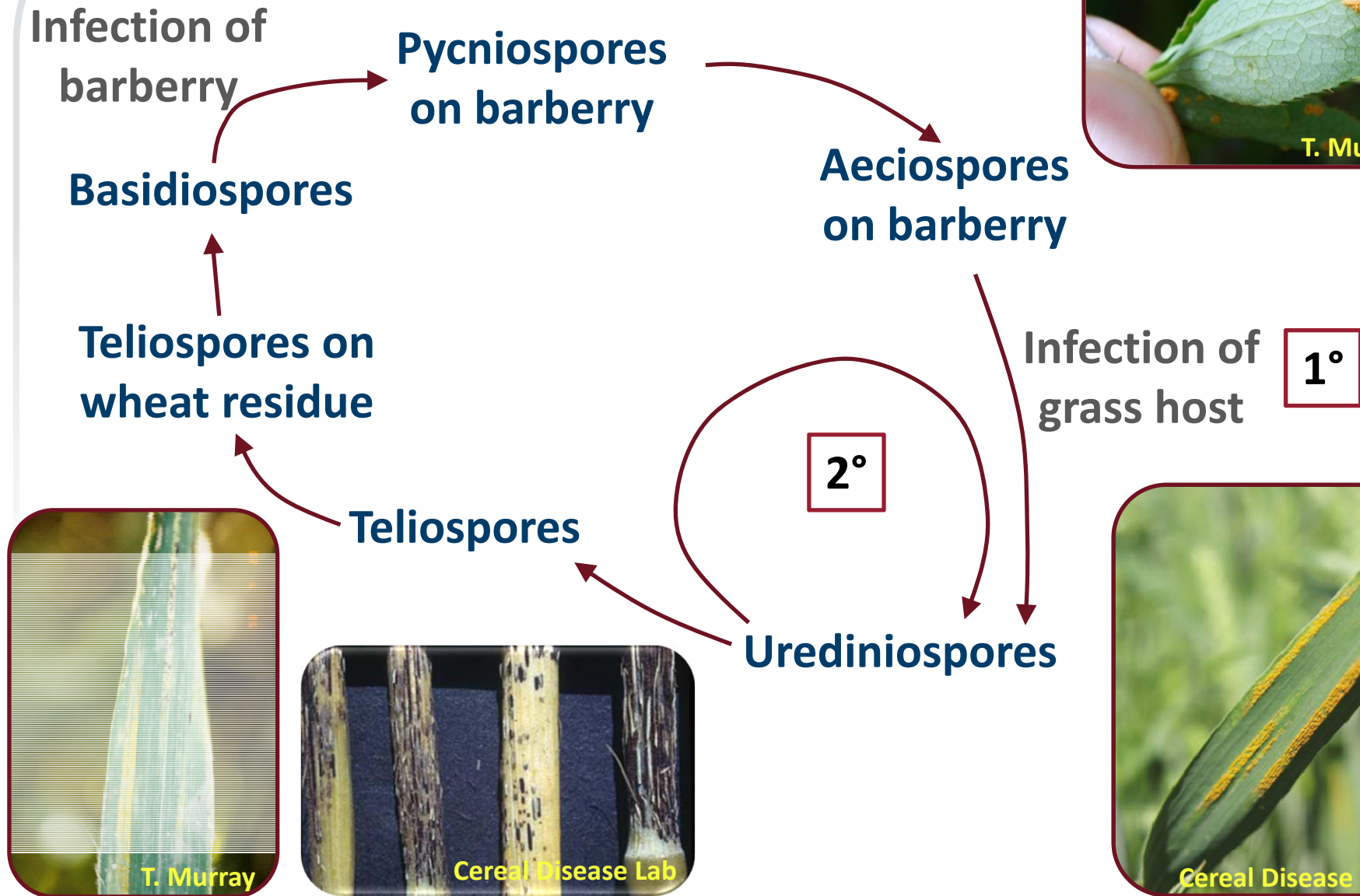
*Puccinia triticina*

Stem rust (black rust) - warm season: 75-86°F

*Puccinia graminis* f. sp. *tritici*

➔ All require dew for spore germination & infection

# Stripe Rust Disease Cycle



## **Factors Affecting Stripe Rust**

### **Favorable temps/moisture for infection**

- temps of 50-64°F w/6 hrs of dew
- cool temps best for disease development, but less important than infection

### **Fall infection**

- susceptible plants in fall

### **Winter survival**

- temperatures during Dec-Feb

# **Stripe Rust Update – December 2016**

**1<sup>st</sup> update by Dr. Chen in January 2017**

**What we know so far:**

- **Rust intensity during summer 2016 was severe due to mild winter and spring weather**
  - **Moist fall conditions have been very favorable for rust development and rust is established**
- ➔ Moderate potential for rust at this point**

**Going forward:**

**Monitor temperatures through December and January**



## Soilborne Wheat Mosaic

04.10.2008



# Soilborne Wheat Mosaic Virus- SBWMV

Soilborne wheat mosaic (SBWM) discovered in 1919 in Illinois → **Rosette disease**

*Polymyxa* identified as the vector in 1960s

First identified in Walla Walla area in spring 2008, but reported in Umatilla Co. in 2005

- Reported in the Willamette valley in 1994

Localized in relatively small area - unknown how widely distributed in county or state

→ **A major problem in the Great Plains and NE US**

## **SBWMV**

**SBWMV was identified at the Arlington, Virginia Experiment Farm in 1925**

- Important site of much early research**
- Now the home of the Pentagon**





# SBWM - Symptoms





## SBWM - Symptoms



## SBWM – Biology

**Disease of fall-sown wheat**

**Transmitted by *Polymyxa graminis***

**→ *acts like other soilborne diseases in terms of distribution within fields and spread***

**Infection occurs in the fall and symptoms appear in early spring**

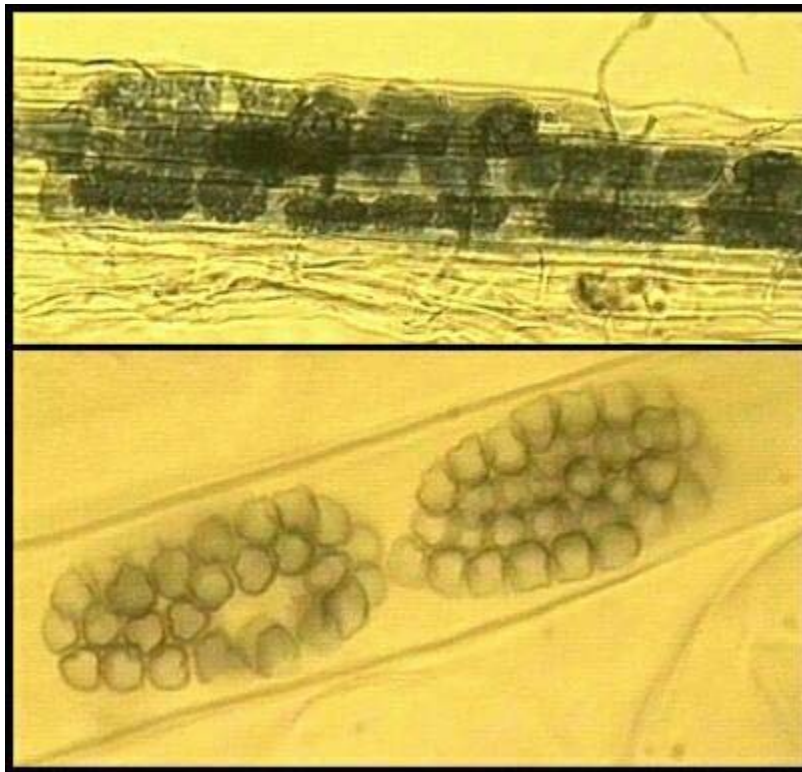
**- symptoms fade and plants appear to recover as temperature increases in spring**

**Damage remains and yield is reduced**

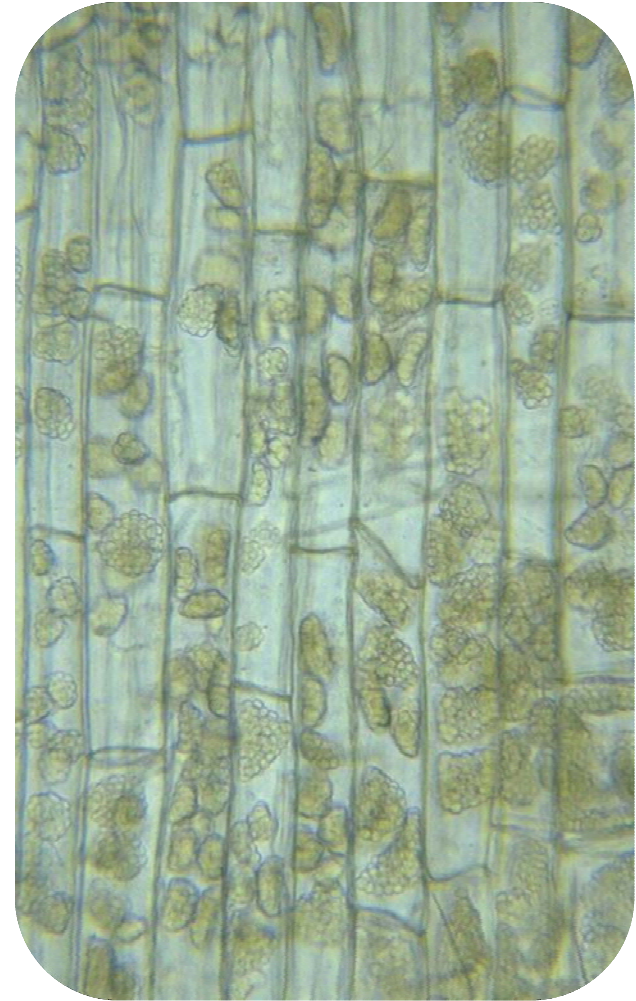


## *Polymyxa graminis*

***P. graminis* infects root hairs and then invades root tissue forming resting spores**

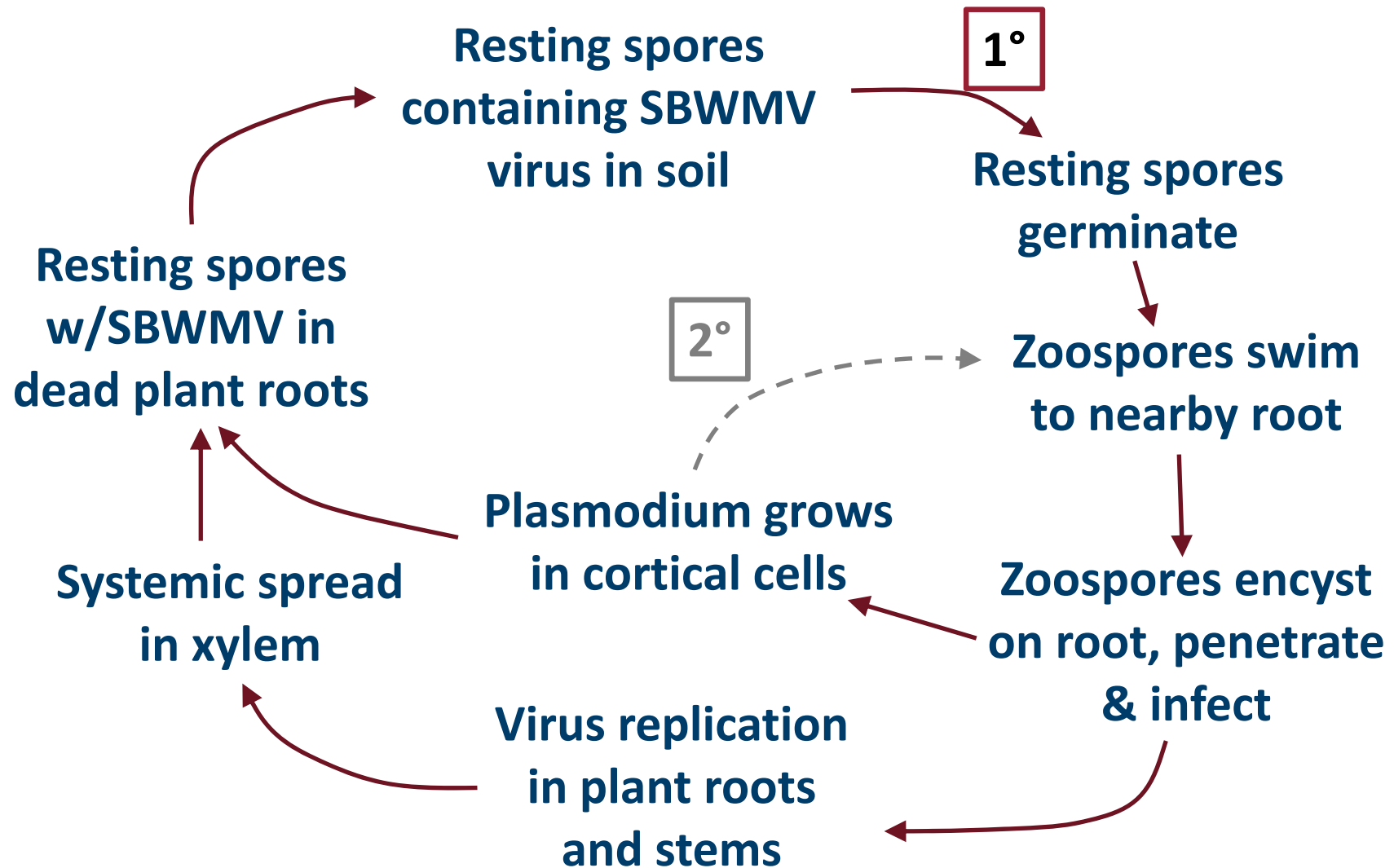


J. Deacon, Univ. Edinburgh



Wikipedia.org

# SBWM – Disease Cycle



## Disease Comparison

Disease	Inoculum		Type
	Primary	Secondary	
Eyespot	Yes	Not important	Monocyclic
Stripe rust	Yes	Yes	Polycyclic
SBWMV	Yes	Not important	Polyetic

# Eyespot Control Options

**Cultural practices**

➔ **seeding date**

**Resistant varieties**

## Resistance to Eyespot, Pullman, WA 2016

Variety	Dis. index	% Lodging	Variety	Dis. index	% Lodging
LCS Colonia	17.5	0	HE 181/3	58.4	26.3
X06134-57C	21.6	0	OR2120276H	63.6	2.8
WA8225	22.3	0	UI WSU Huffman	65.0	5.5
Madsen	23.3	0	WA8245	65.1	6.3
LWW14-71032	26.3	1.3	Eltan	66.0	68.8
WA8187	26.9	0	LWW14-73163	66.9	12.5
X06132-45C	28.3	1.0	OR2110664	68.1	1.0
IDN 01-10704A	29.8	0	09PN062#18	68.3	17.5
ARS Crescent	31.6	0.5	A10601WDH061	69.9	13.8
04PN077-23	35.6	0	04PN096-2	72.6	20.5
WA8243	36.1	0	KXB01	72.9	70.0
X010679-1C	39.1	5.0	ORLD2112334	73.2	27.5
X06135-9C	41.6	4.3	MT1257	74.7	90.0
LWW14-73161	42.0	16.8	ID DB44	77.2	1.0
WA8202	42.5	32.5	ORLD2113092	79.2	56.3
04PN028B-3	42.7	0	OR2110679	80.7	35.0
X20060123-0-31C	43.4	10.0	MT1356	81.6	90.0
MAS08019-94-1-S-s	44.3	1.8	MT1354	89.4	96.3
IDN 02-29001A	44.4	0	MTS1224	91.3	98.8
WA8234	44.5	0.5	A10601WDHG073	91.7	73.8
WA8244	48.9	1.8	Mean	55.1	24.5
LWW14-71195	49.0	1.3	LSD 5%	15.9	17.1

## Eyespot Resistant Winter Varieties

- AP700CL
- AP Legacy
- ARS Chrystal
- ARS Selbu
- Brundage 96
- Cara
- Chukar
- Coda
- Jasper
- LCS-Azimut
- LCS-Colonia
- Madsen
- Masami
- Northwest 553
- ORCF-102
- Otto
- Puma
- Rosalyn
- Tubbs 06
- WB 456
- WB 523
- WB 528
- WB 1066CL

Soft white, Hard red, Club



# Eyespot Control Options

Cultural practices

→ seeding date

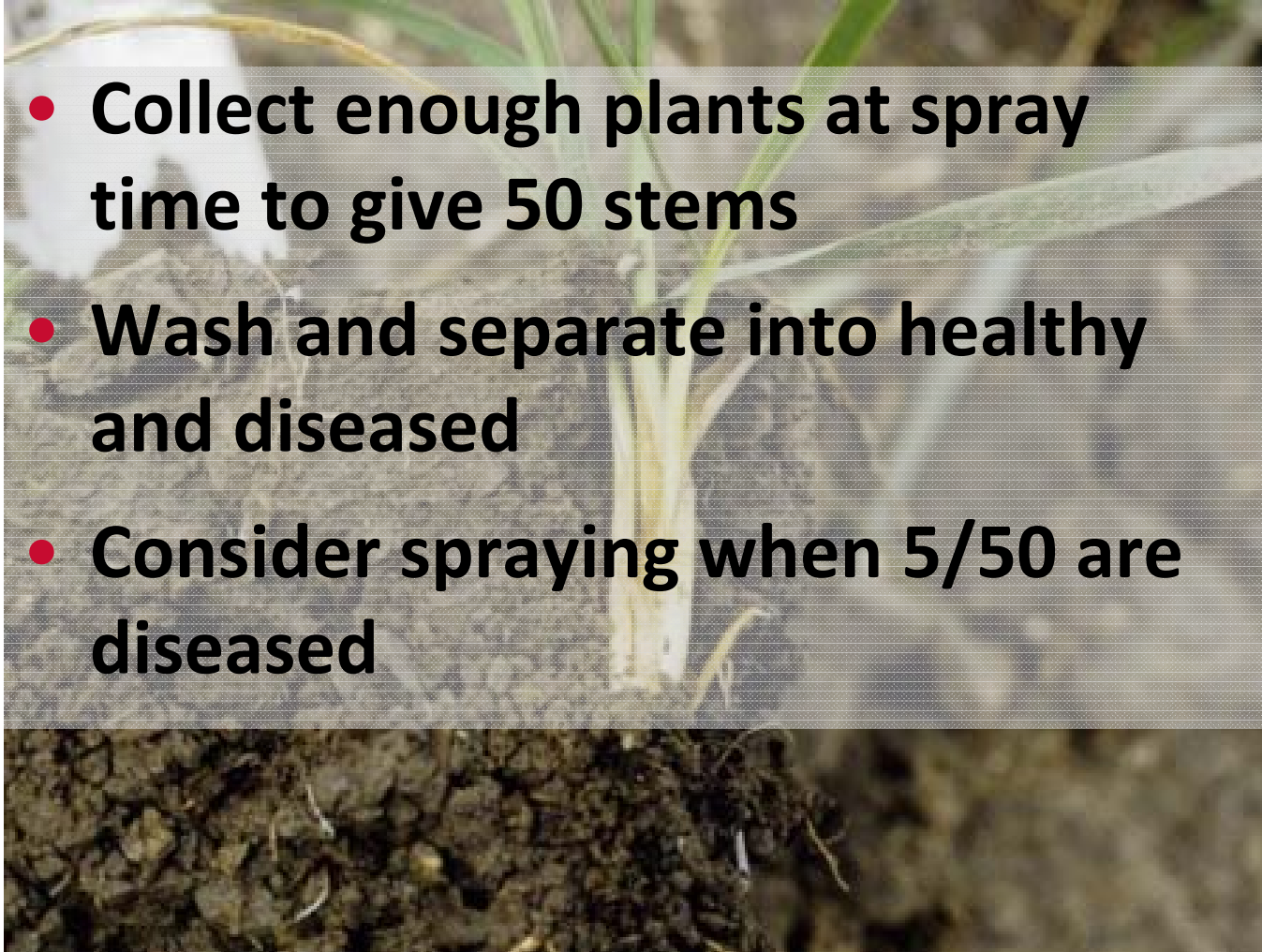
Resistant varieties

**Foliar fungicides**

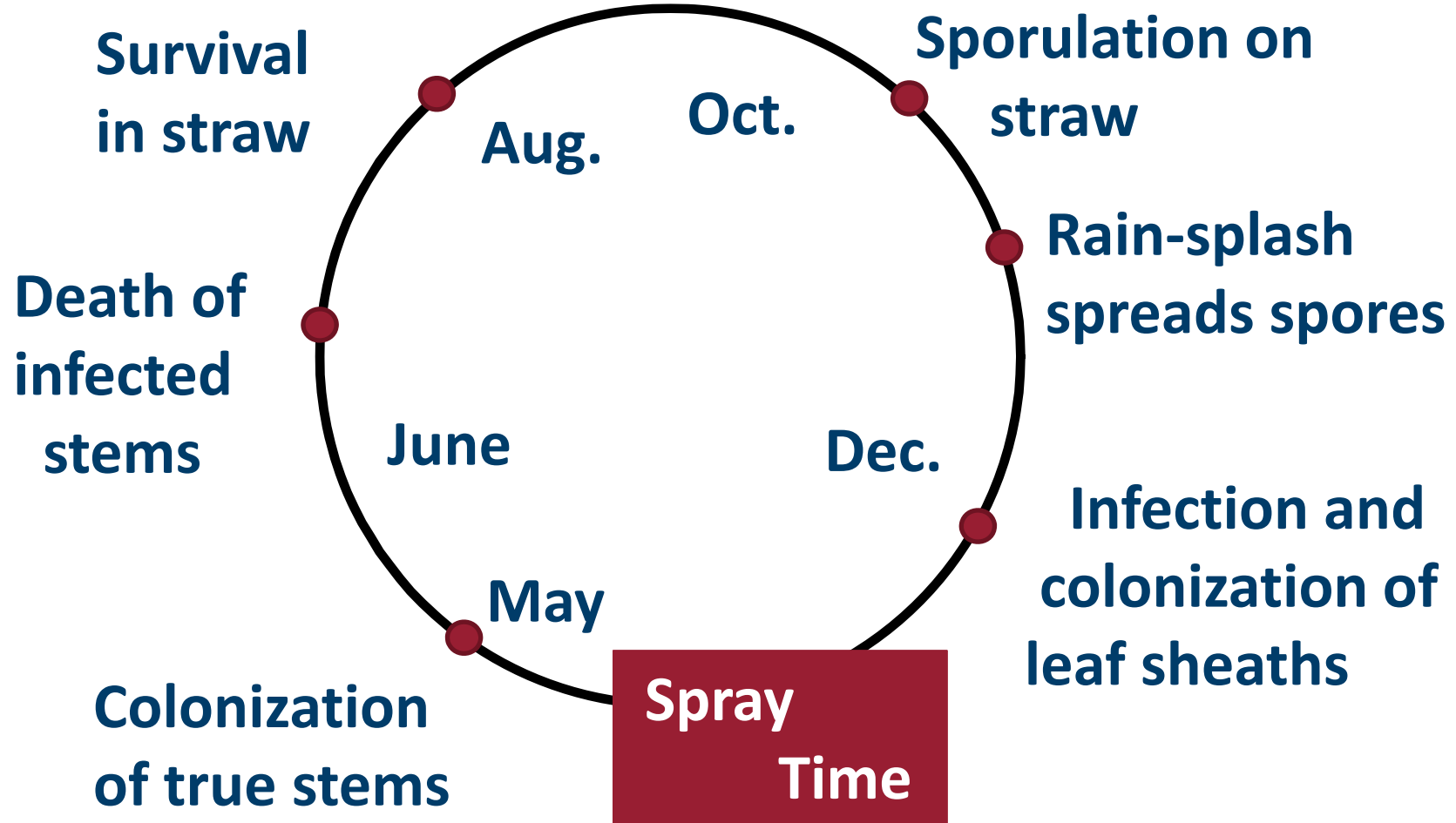
## When to Spray?

“the 10% rule”

- Collect enough plants at spray time to give 50 stems
- Wash and separate into healthy and diseased
- Consider spraying when 5/50 are diseased



## Eyespot Disease Cycle



## What to Spray?

**Tilt + Topsin-M (4 oz + 10 oz)**

**(propiconazole + thiophanate-methyl)**

**Alto + Topsin-M (3.0-5.5 oz + 10 oz)**

**(cyproconazole + thiophanate-methyl)**

**Nexicor (9-13 oz)**

**(fluxapyroxad + pyraclostrobin + propiconazole)**

**Priaxor (6-8 oz)**

**(fluxapyroxad + pyraclostrobin)**

**Quilt + Topsin-M (14 oz + 10 oz)**

**(propiconazole + azoxystrobin + thiophanate-methyl)**

## Fungicides for Eyespot Control, Knodel Farms, Ralston, WA 2015

<b>Treatment</b>	<b>Rate prod/ac</b>	<b>Lesion severity 0 - 4</b>	<b>% infected stems 0 – 100</b>	<b>Disease index 0 - 100</b>	<b>Yield bu/ac</b>	<b>Test weight lbs/bu</b>
<b>Priaxor</b>	<b>8 fl oz.</b>	<b>1.9</b>	<b>64.8</b>	<b>31.0</b>	<b>47.2</b>	<b>56.6</b>
<b>Tilt + Topsin-M</b>	<b>4 fl oz + 20 fl oz</b>	<b>2.1</b>	<b>79.4</b>	<b>41.6</b>	<b>50.7</b>	<b>56.8</b>
<b>Alto</b>	<b>5.5 fl oz.</b>	<b>2.1</b>	<b>81.4</b>	<b>42.6</b>	<b>48.4</b>	<b>56.6</b>
<b>Untreated control</b>	<b>-</b>	<b>2.2</b>	<b>87.5</b>	<b>48.3</b>	<b>46.3</b>	<b>56.3</b>
	<b>LSD</b>	<b>NS</b>	<b>12.0</b>	<b>10.5</b>	<b>NS</b>	<b>NS</b>
	<b>P-value</b>	<b>0.16</b>	<b>0.01</b>	<b>0.02</b>	<b>0.42</b>	<b>0.896</b>

## Fungicides for Eyespot Control, Warren Farms, Dayton, WA 2015

<b>Treatment</b>	<b>Rate prod/ac</b>	<b>Lesion severity 0 - 4</b>	<b>% infected stems 0 - 100</b>	<b>Disease index 0 - 100</b>	<b>Yield bu/ac</b>	<b>Test weight lbs/bu</b>
<b>Priaxor</b>	<b>8 fl oz</b>	<b>1.7</b>	<b>65.2</b>	<b>27.5</b>	<b>74.6</b>	<b>54.9</b>
<b>Tilt + Topsin-M</b>	<b>4 fl oz + 20 fl oz</b>	<b>2.0</b>	<b>90.4</b>	<b>44.3</b>	<b>69.5</b>	<b>54.7</b>
<b>Alto</b>	<b>5.5 fl oz.</b>	<b>1.8</b>	<b>89.6</b>	<b>39.9</b>	<b>67.4</b>	<b>55.0</b>
<b>Untreated control</b>	<b>-</b>	<b>1.9</b>	<b>85.3</b>	<b>41.1</b>	<b>72.8</b>	<b>55.2</b>
	<b>LSD</b>	<b>NS</b>	<b>15.9</b>	<b>12.4</b>	<b>NS</b>	<b>NS</b>
	<b>P-value</b>	<b>0.32</b>	<b>0.01</b>	<b>0.05</b>	<b>0.65</b>	<b>0.96</b>

# Stripe Rust Control Options

**Plant disease resistant varieties**

➔ **preferably those with HTAP resistance**

**Cultural**

**Green bridge management**

**- reduce volunteer & grassy weeds**

**Avoid early planting**

**Avoid excessive irrigation**

**- furrow better than sprinkler**

**Balanced fertility; don't over fertilize with N**

**Monitor rust forecast, scout fields, spray fungicides  
when necessary**



# Stripe Rust Reactions



**Resistant**



**Intermediate**



**Susceptible**

[striperustalert.wsu.edu](http://striperustalert.wsu.edu)



## Stripe Rust Resistant Winter Varieties, WSCIA 2015-16 Portfolio

Rating	Varieties
R (1,2)	Amber, AP700CL, Bobtail, Bruneau, <b>Cara</b> , <b>Chukar</b> , <b>Farnum</b> , <b>LCS Azimut</b> , Legion, Madsen, <b>Norwest 553</b> , Otto, Rosalyn, Selbu, Skiles, <b>Sprinter</b> , SY Ovation, WB1066CL, WB1070CL
MR (3,4)	Bitterroot, <b>Bruehl</b> , <b>Chrystal</b> , <b>Coda</b> , <b>Crescent</b> , Curiosity CL+, <b>Finley</b> , Jasper, <b>Keldin</b> , Kaseberg, LCS Artdeco, <b>LCS Colonia</b> , Mary, Masami, ORCF 102, Puma, Stephens, SY 107, UICF Brundage, WB456, WB523, WB528, WB Junction, <b>Whetstone</b> , <b>SY Clearstone CL2</b>
M (5)	AP Badger, <b>AP503 CL2</b> , <b>Boundary</b> , Eltan, Ladd, Mela CL+, Xerpha,
MS (6,7)	AP Legacy, <b>Bauermeister</b> , Brundage 96, ORCF 103, <b>WB Rimrock</b> , Tubbs 06, <b>WB Arrowhead</b> ,
S (8,9)	Goetze
Soft white, <b>Hard red</b> , <b>Club</b>	

## Stripe Rust Resistant Spring Varieties

### WSCIA 2015-16 Portfolio

Rating	Varieties
R (1,2)	Seahawk, Dayn, JD, SY Basalt, WB6121, WB9518,
MR (3,4)	Alum, Chet, Diva, Glee, Louise, SY Steelhead, UI Platinum, Whit
M (5)	Bullseye, UI Stone, WB6341
MS (6,7)	Cabernet, Kelse, Snow Crest, UI Pettit, WB1035 CL+, WB Hartline, WB Paloma
S (8,9)	Babe, SY605CL2, WB Fuzion
Soft white, Hard red, Hard white	

# Fungicides

**Monitor forecasts and development of rust**

**→ Scout, Scout, Scout!**

**Spray when necessary:**

**Spray when susceptible varieties have 1 to 5%  
active rust**

## What Does 5% Rust Look Like?

