

Managing Disease Resistance: Implications for Soybean Rust

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Major Gene

Qualitative

Complete

Race-specific

Specific

Vertical

Intolerance

Minor Gene

Quantitative

Partial

Non-specific

General

Horizontal

Tolerance

Major Gene Resistance

- Single gene
- Usually dominant
- Often gives complete resistance
- Relatively straightforward to work with in a breeding program
- Highly specific to pathogen race
- Very often unstable over time

Major Genes

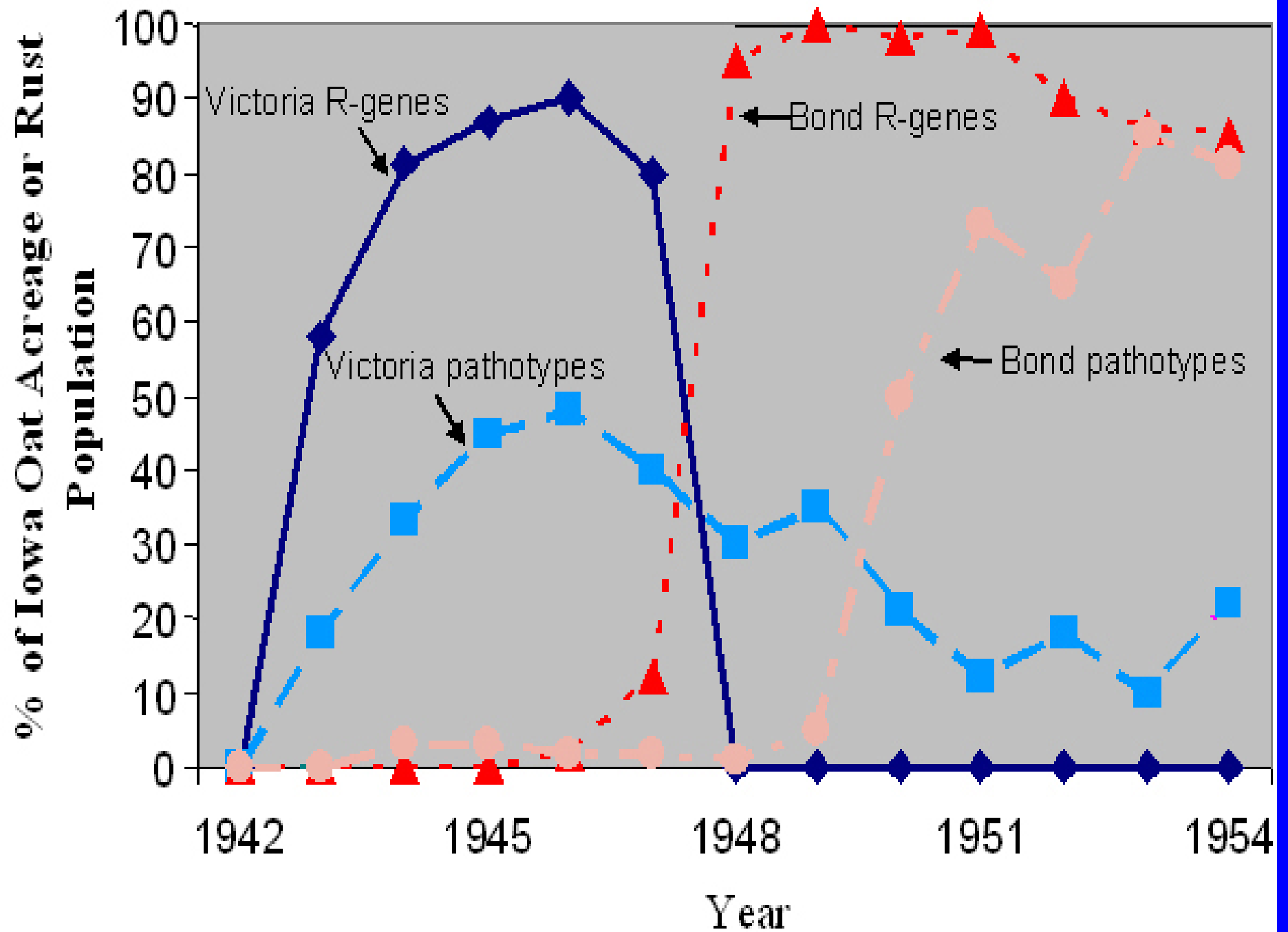
Interact With the Pathogen in
a “Gene-for-Gene” System

How Does This Work??

Major Genes

Very Easy for the Pathogen to Overcome

Results in “Boom-and-Bust” Cycles



Minor Gene Resistance

- Multiple gene inheritance
- Often recessive
- Usually gives incomplete resistance
- Can be more complicated to work with
- Not highly specific
- Tends to be very stable over time

Strategies for Major Genes

One gene at a time

Gene rotation

Gene “pyramids”

Mixtures

Regional deployment

Working With Minor Genes

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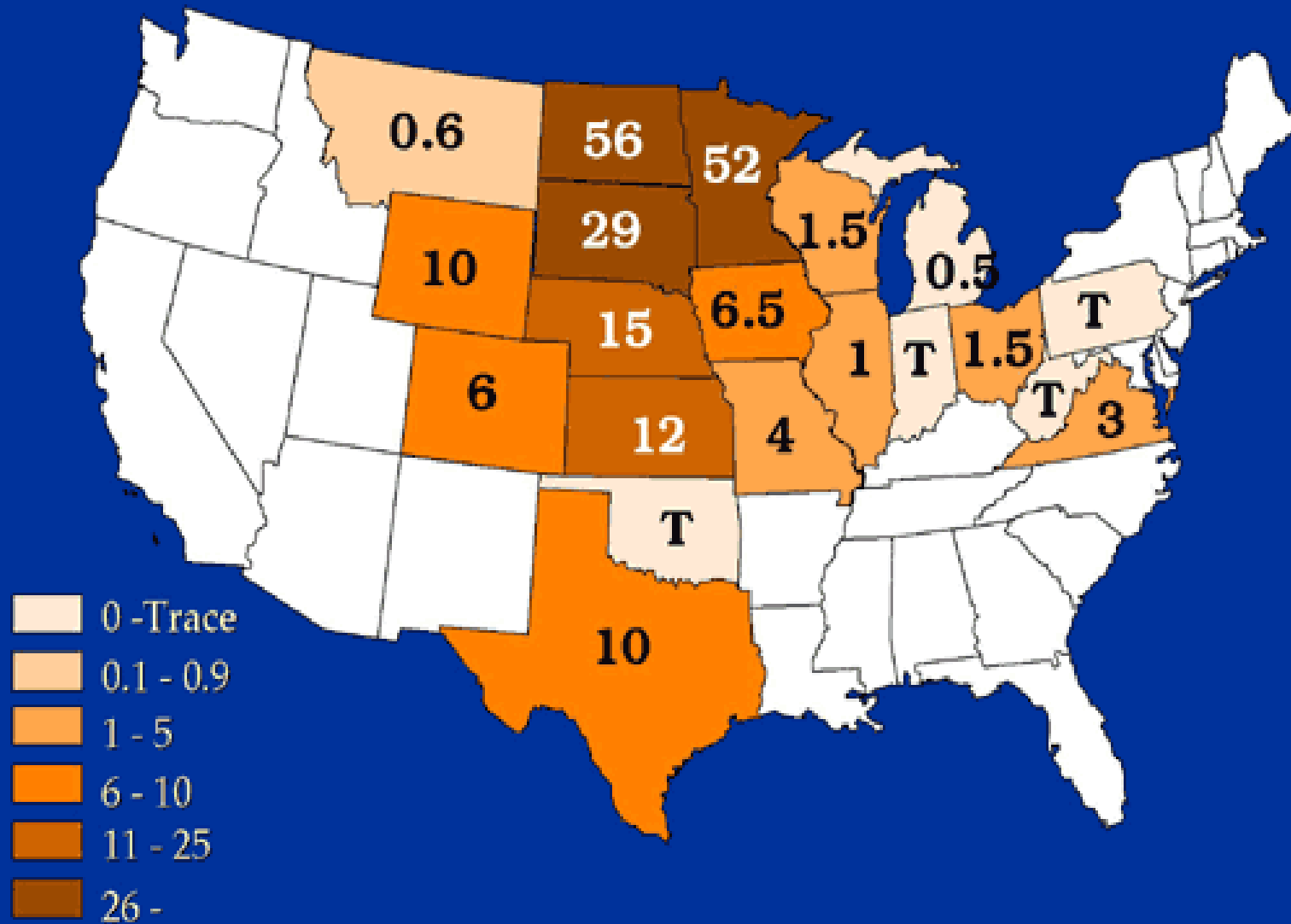
Mixtures

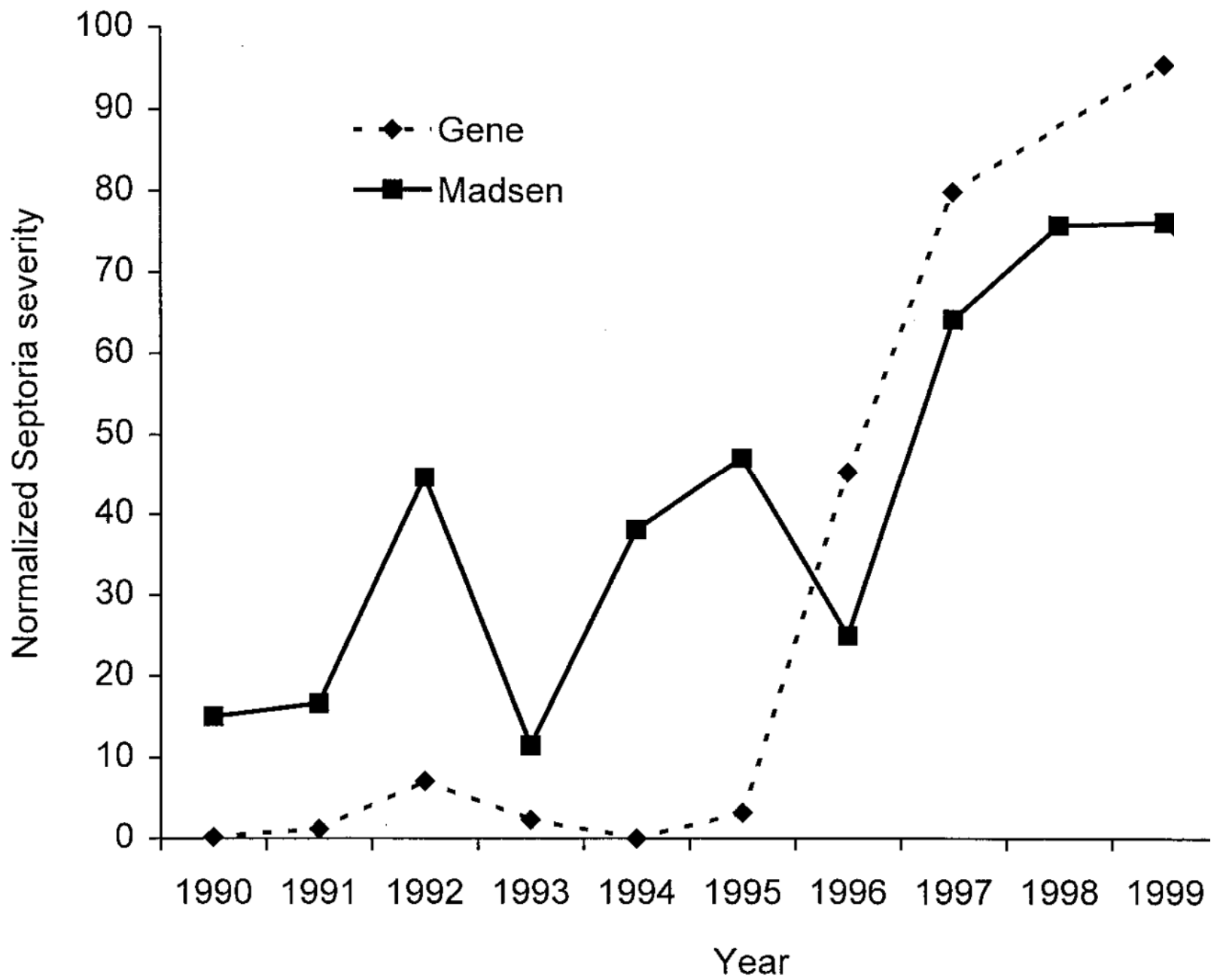
Regional deployment

Working With Minor Genes



1935 % Loss to Wheat Stem Rust After Barberry Eradication





Lessons:

Single major genes are usually unstable and make crops vulnerable to sudden yield losses

Don't believe that your
favorite resistance
gene is an exception

“Silver Bullets” Usually
Aren't

Strategies for Major Genes

One gene at a time

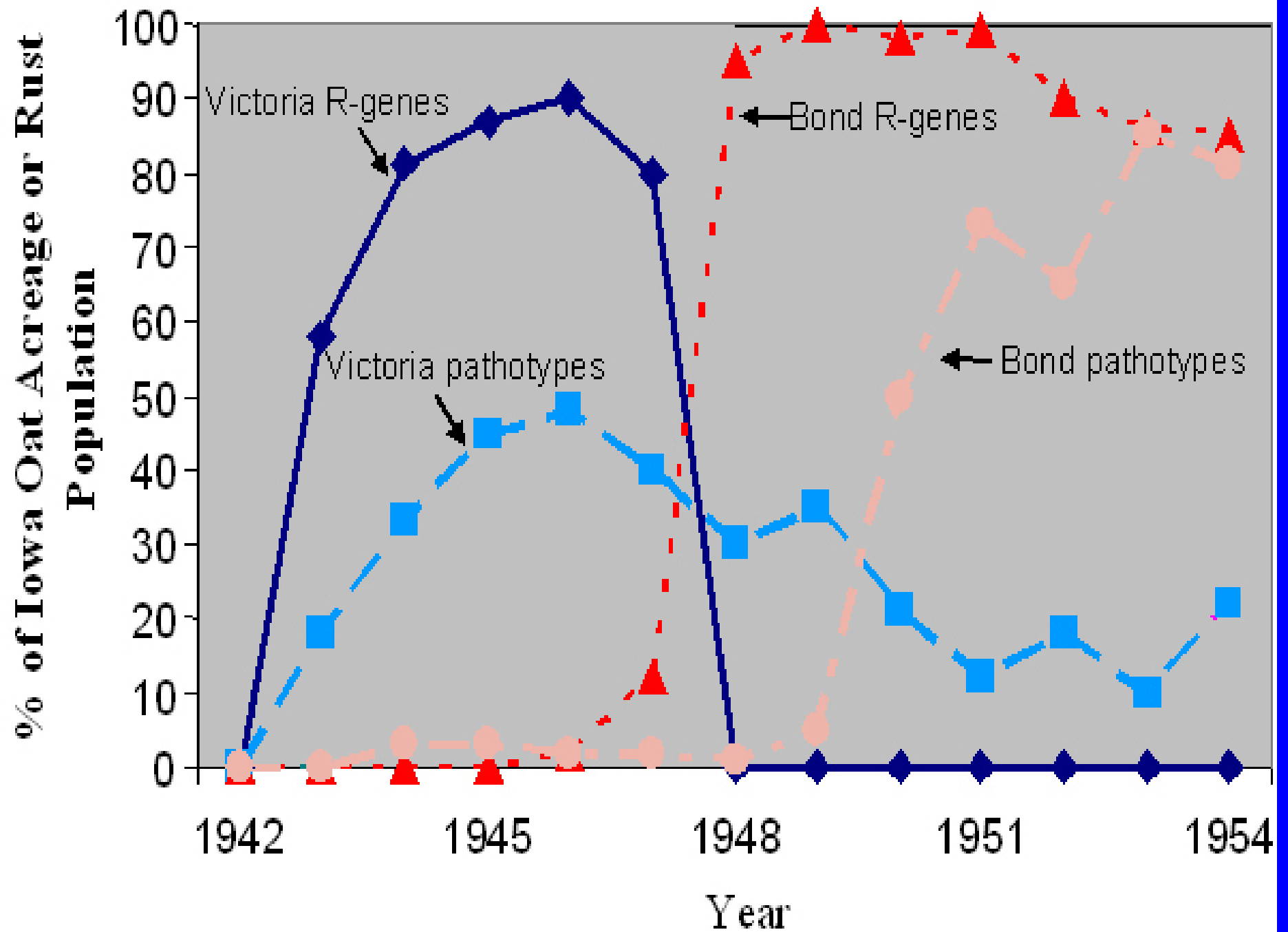
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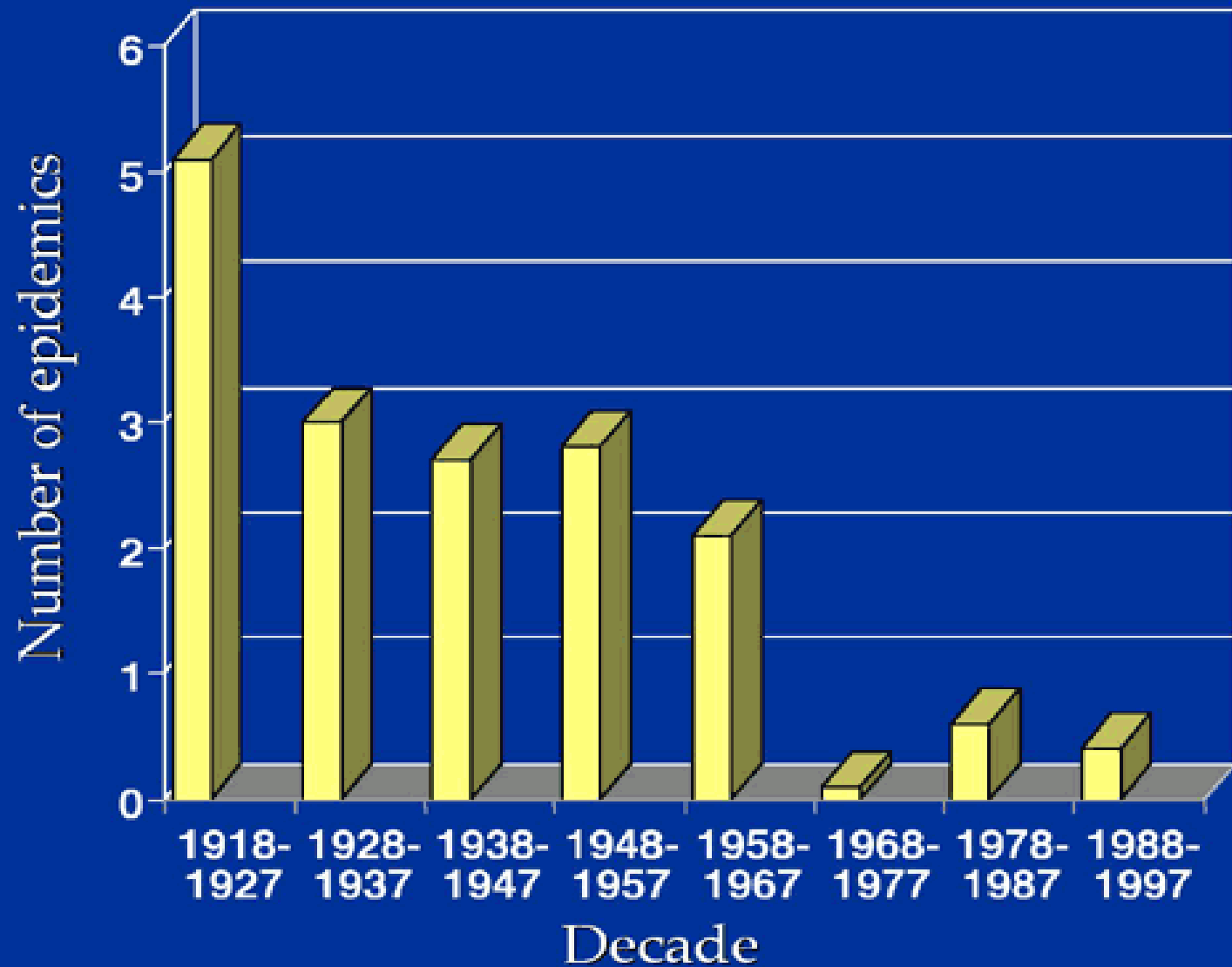
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Regional deployment

Working With Minor Genes

- Probability of multiple mutations
- Residual gene effects
- Favorable combinations

Average Number of Wheat Stem Rust Epidemics in Barberry Eradication Area



Year Cultivar	licensed	Rust reaction		Known resistance genes
		When licen.	1978	
Kota	Pre-1923	S	S	<i>Sr28</i>
Marquis	Pre-1923	S	S	<i>Sr7b, 18, 19, 20</i>
Red Bobs	1926	S	S	<i>Sr7b, 10</i>
Reliance	1932	S	S	<i>Sr5, 16, 18, 20</i>
Thatcher	1935	R	S	<i>Sr5, 9g, 12, 16</i>
Renown	1937	R	S	<i>Sr2, 7b, 9d, 17</i>
Redman	1946	R	S	<i>Sr2, 7b, 9d, 17</i>
Lee	1950	R	S	<i>Sr9g, 11</i>
Selkirk	1953	R	R	<i>Sr2, 6, 7b, 9d, 17, 23</i>
Canthatch	1959	MR	S	<i>Sr5, 7a, 9g, 12, 16</i>
Pembina	1959	R	R	<i>Sr2, 5, 6, plus</i>
Manitou	1965	R	R	<i>Sr5, 6, 7a, plus</i>
Neepawa	1969	R	R	<i>Sr5, plus</i>
Pitic 62	1969	R	S	<i>Sr8, 9b</i>
Napayo	1972	R	R	<i>Sr5, 6, 7a, plus</i>

Sr2, Sr6, Sr17, Sr24,
Sr31, Sr36, Sr38

POSSIBLE MIGRATION ROUTES OF WHEAT RUST Ug99

Based on prevailing winds and areas of wheat production, route A via the Arabian peninsula is considered the more likely route for the continuing advance of the disease



1999 – Race TTKSK
(Sr31 + Sr38)

2006 – Race TTKST
(Sr31 + Sr38 + Sr24)

Race TTTSK
(Sr31 + Sr38 + Sr36)

Lesson: Pyramids have
been highly useful, but
may not be permanent

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Working With Minor Genes

A A A A B C A B

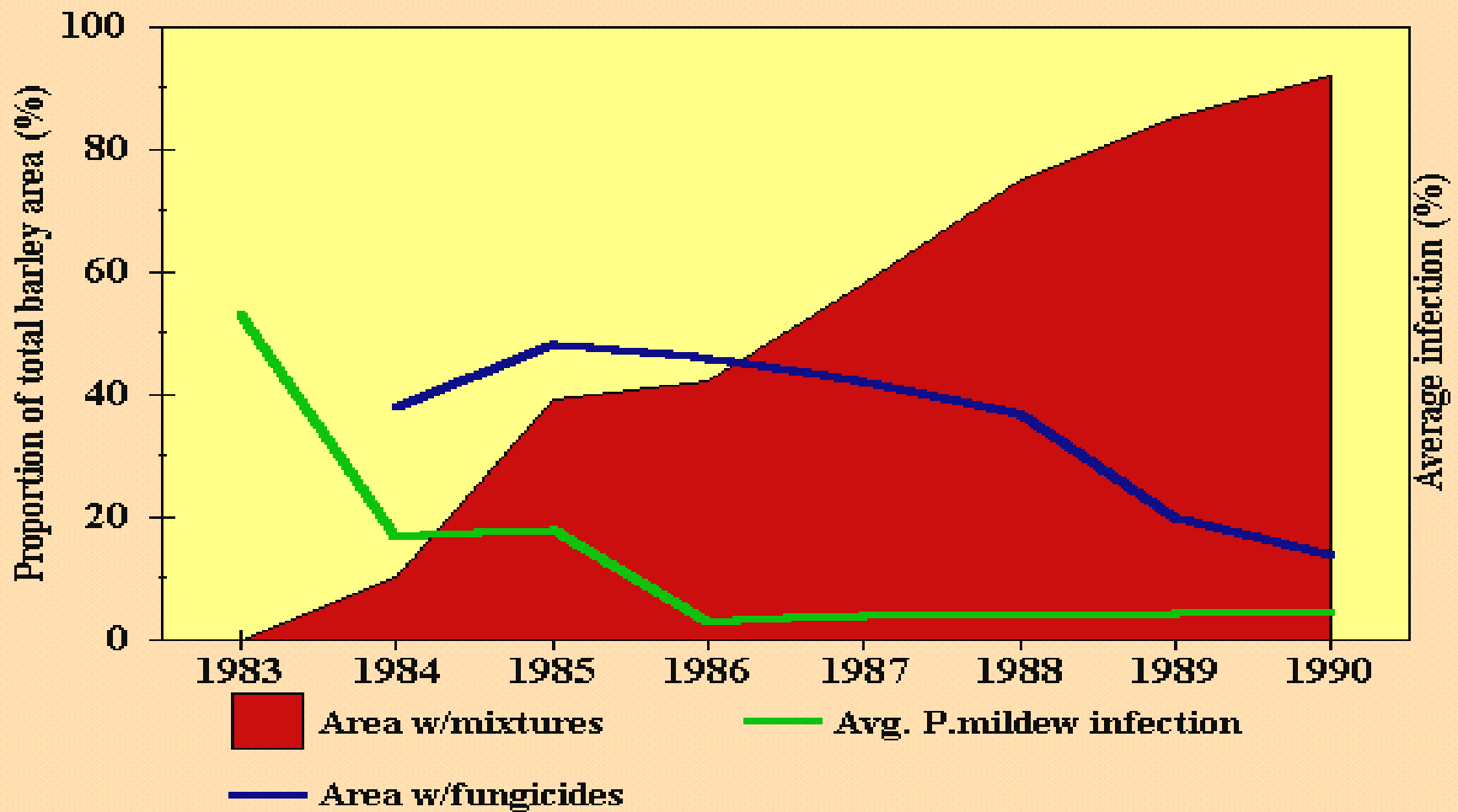
A A A A A B C A

A A A A C A B C

A A A A B C A B

Percent of winter wheat sown to cultivar mixtures in 2008 (source: NASS)

- Oregon 12%
- Washington 25%
- Kansas 10%



Wolfe, 1992



Strategies for Major Genes

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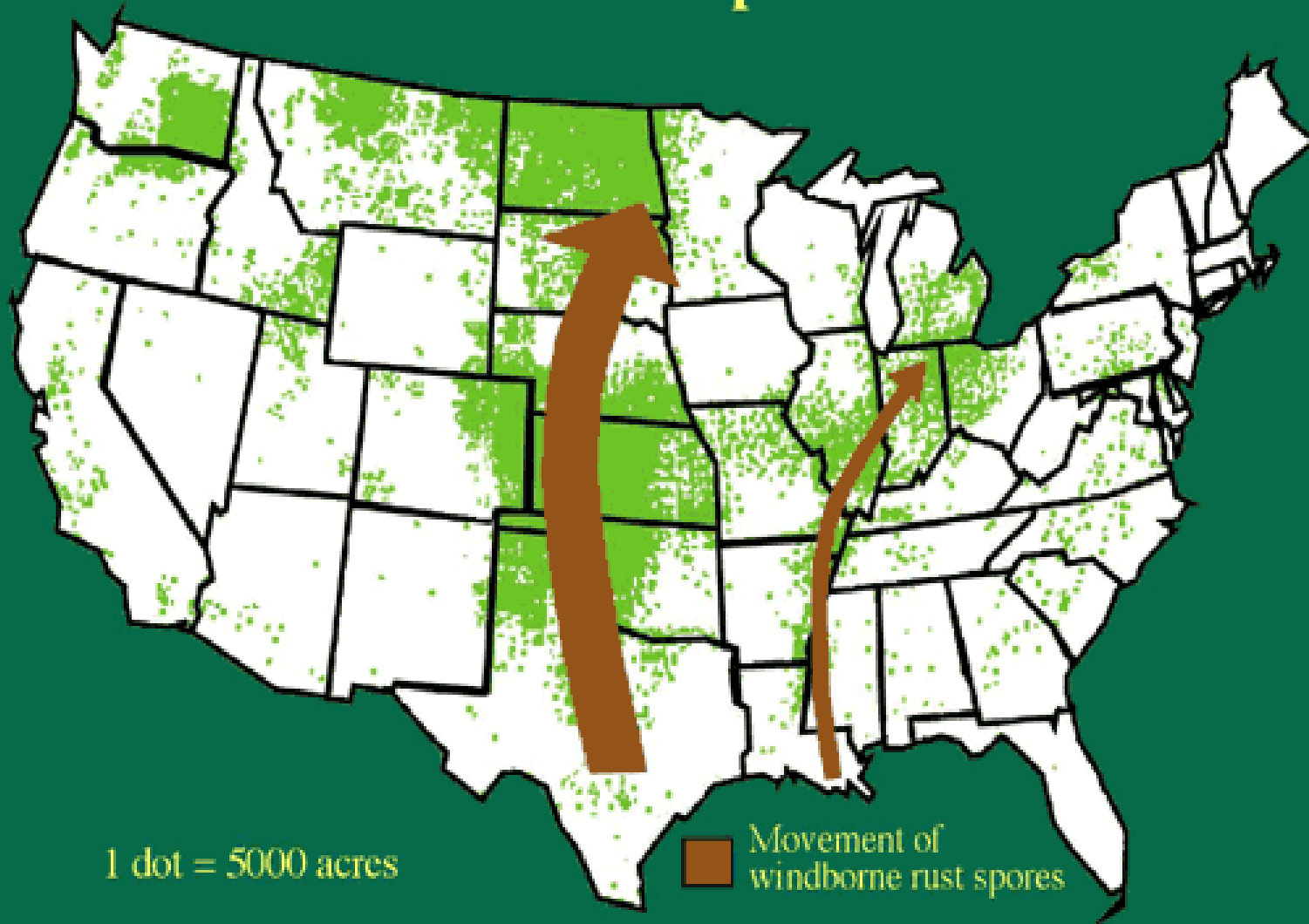
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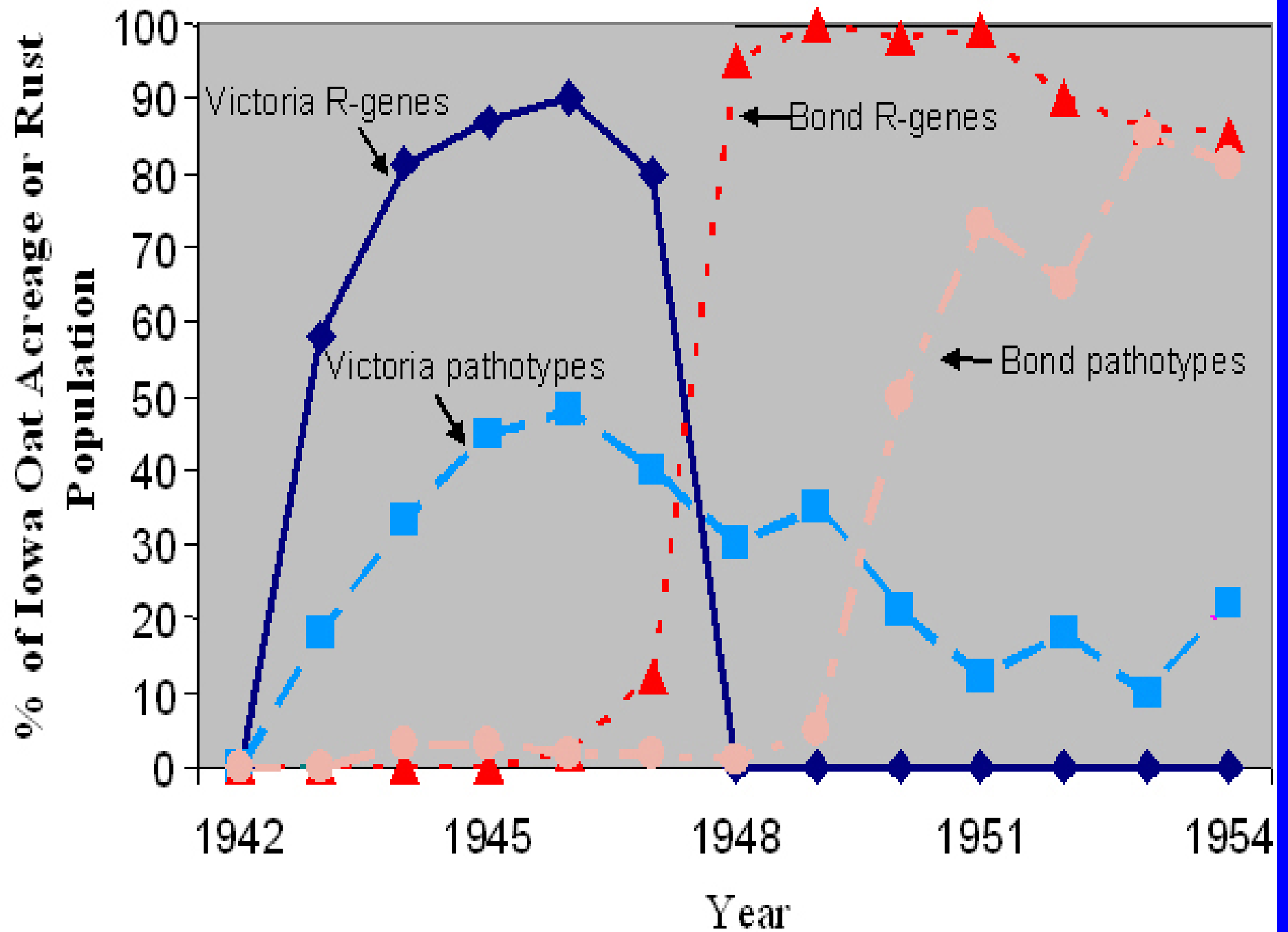
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Regional deployment

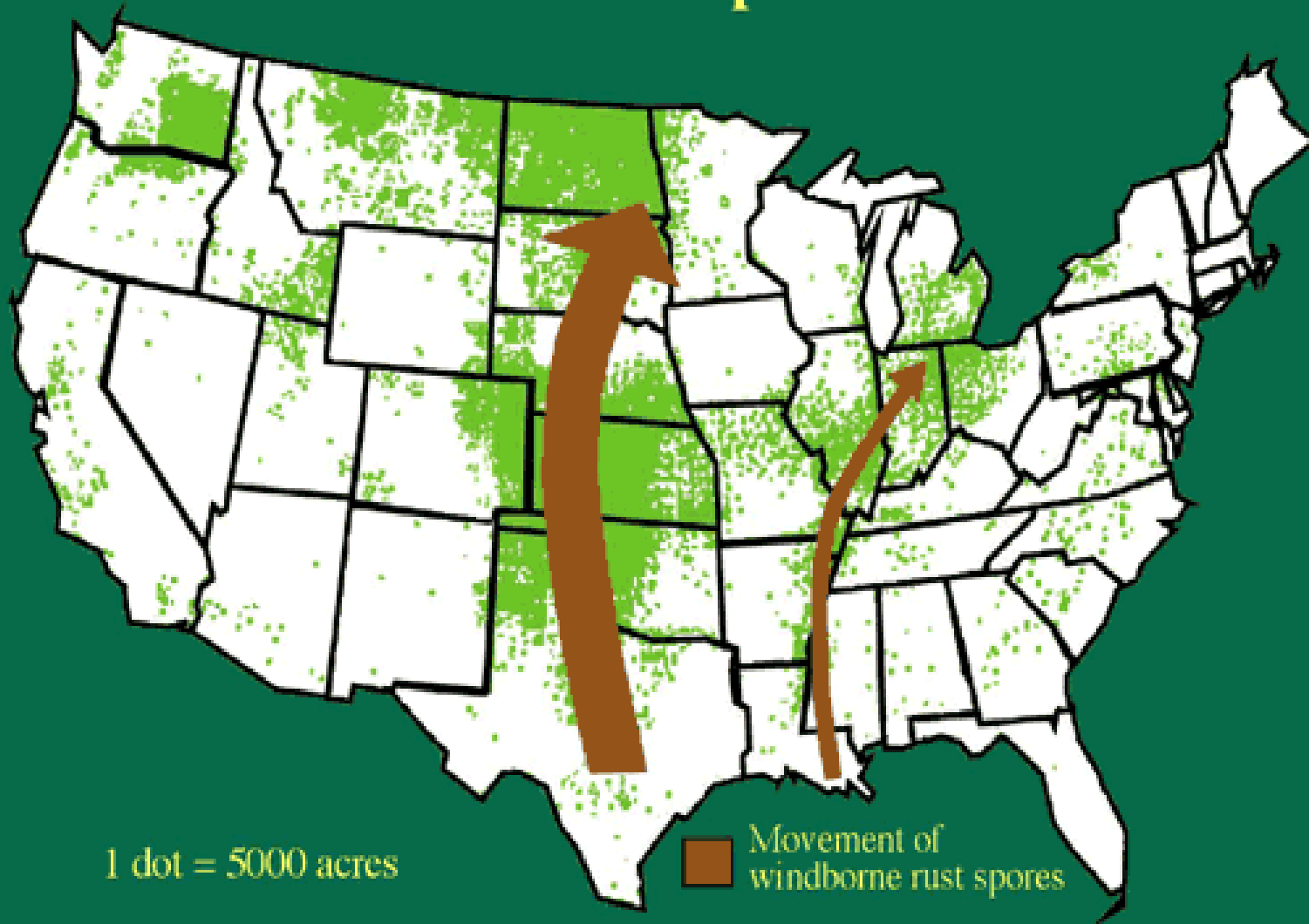
Working With Minor Genes

Wheat Production and the Annual Spread of Rust Epidemics





Wheat Production and the Annual Spread of Rust Epidemics



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Minor Gene Resistance

- Often more available than we think
- Simply purging the most susceptible material can be very useful
- Inheritance is much less complex than once thought

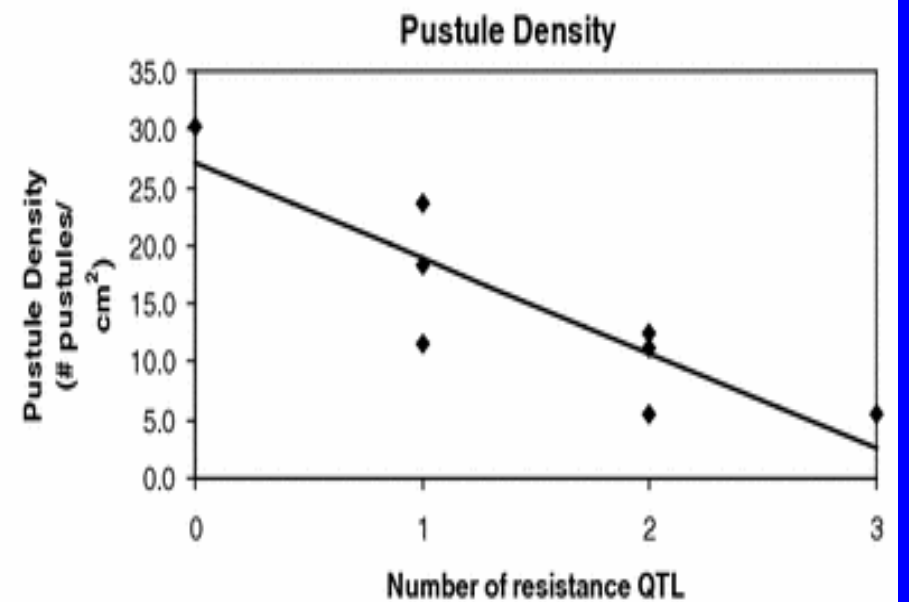
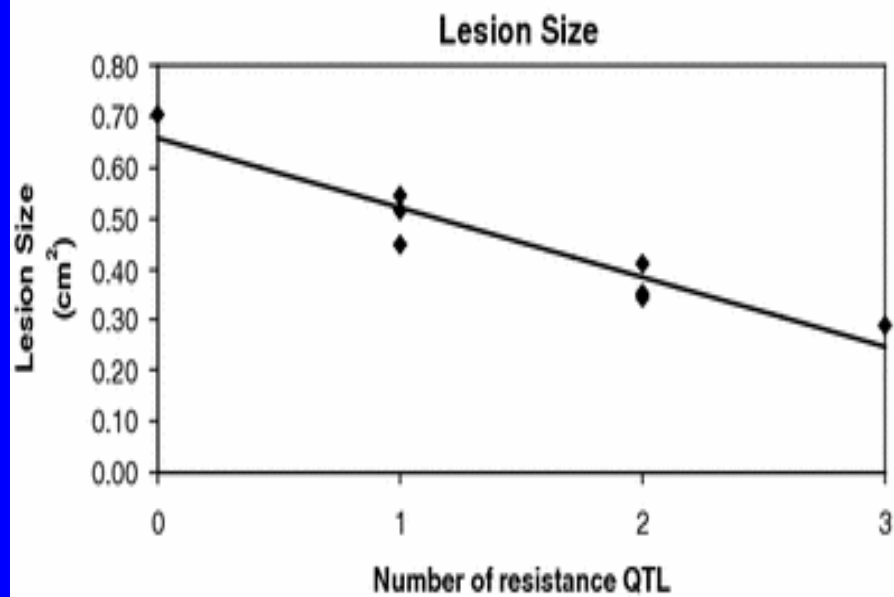
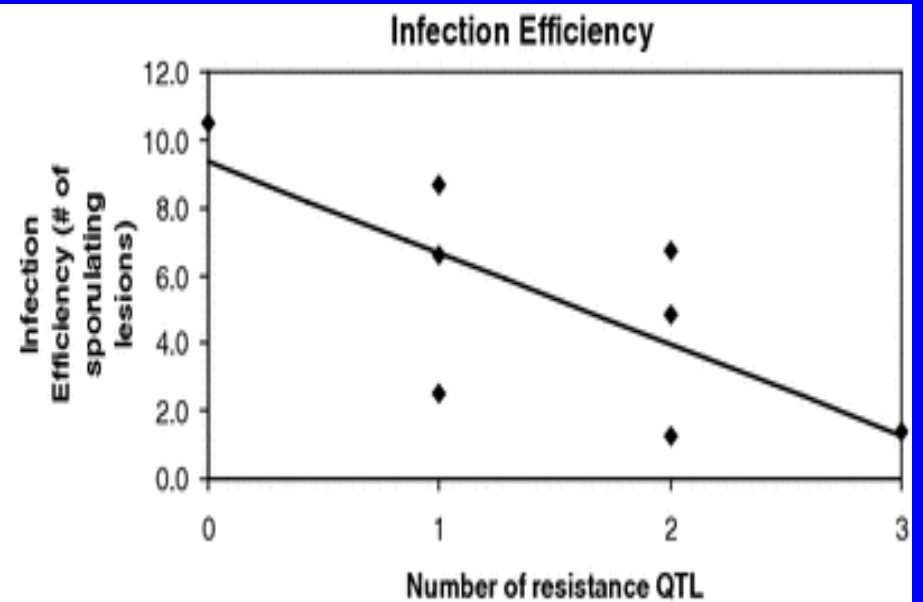
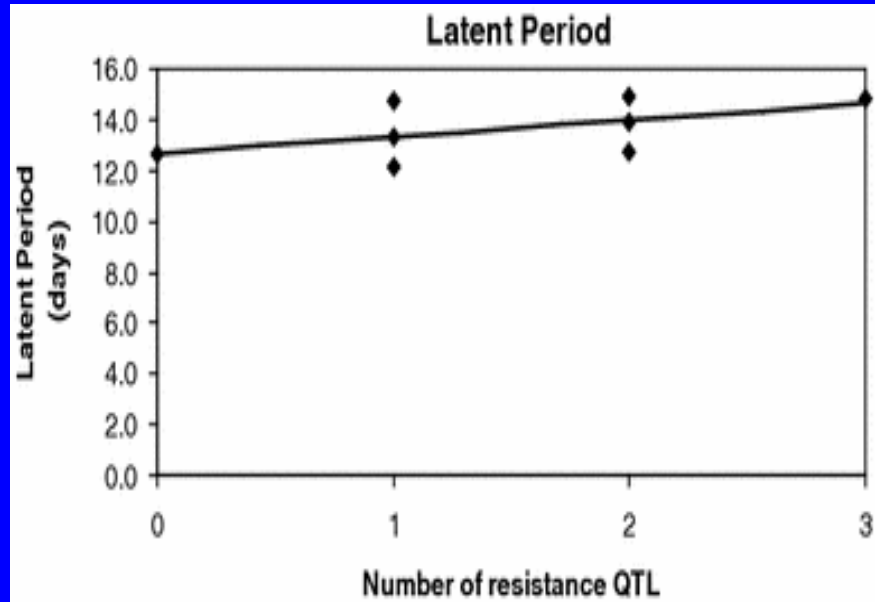
Minor Gene Resistance

Commonly only 2-4 genes identified

1 or 2 that contribute majority of effect

Heritability usually moderate to high

“Components” of resistance usually controlled by the same genes



Can be relatively easy to
maintain minor gene
resistance once you
have it

Stripe Rust

Puccinia striiformis



Use of Top Crosses to
Maintain Minor Genes
for Stripe Rust
Resistance While
Improving Other Traits

Vertifolia Effect

Percent of Willamette Valley Winter Wheat Acreage Planted to 'Foote'

Year	Percent
2001	22
2002	50
2003	50
2004	51
2005	32
2006	4

Lessons:

The Vertifolia Effect can be
real

“Perfect Storms” do happen

Summary

How I Look at the
Soybean Rust
Situation From An
Outside Perspective

Single Gene at a Time “Use It Till You Lose it”

- May be needed as a stop-gap measure
- In general, don't go there
 - Puts growers at risk
 - Disruptive to breeding programs

Rotating Genes

- Likely a disaster
- Virulence unlikely to decline to previous levels

Pyramids or Combinations of Major Genes

- Useful in increasing durability of major genes
- More complex than using single genes
- Takes time to determine which combinations work best

Mixtures or Blends of Major Genes

- Not much information available for soybean rust
- Perhaps worth investigating

Regional Deployment

- Likely very useful if done
- Is it feasible?

Minor Gene Resistance

- It's hard to go wrong with this approach
- May take a bit more effort up front
- Likely to eliminate a lot of headaches in the longer term

Don't Forget About IPM

Potato late blight severity:

Susceptible, no fungicide =	100%
Weekly fungicide =	56%
Minor gene resistance =	46%
Resistance + fungicide =	9%

*Free Advice is Often Worth
What You Pay For It*