

Refining the Generic Model for Disease Recovery Plans for the National Plant Disease Recovery System (or) Are We Finally Getting Closer to Generic Plans?

5th National Plant Disease Recovery System Workshop
Apr 14-16, 2013, Falls Church, VA

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Refining the Generic Model for Disease Recovery Plans

1. Ray Martyn – Background and how we got to where we are now – the generic plan concept and the cluster analysis model.
2. Neil M^cRoberts – Defining and validating the model.
3. Carla Thomas – How can we use this to build generic recovery plans?
4. Breakout session – Where do we go from here, if anywhere?

Prioritizing Plant Diseases for the NPDRS

- 1st NPDRS Workshop – April 2006 (Memphis, TN)
 - What is a recovery plan and how to select pathogens for a recovery plan
 - (Old M^cDonald's farm – your list, my list, here a list, there a list, everybody's list list - pathogen du jour)

Historical Background

Criteria for prioritization

- USDA Select agents and toxins list ✓
- Economic value of host crop
- Risk assessment criteria
- Type of pathogen (Taxa)
- Type of host (crop)
- Type of host x type of pathogen matrix

Host x Pathogen Taxa

Host

Pathogen Taxa	Forage	Small grains	Field crops	Fruits & Nuts	Forest & Landscape	Veggies	Orna-mentals
	Viruses	X	X				
	Bacteria						
	Fungi (Rusts)			X		X	
	Fungi (Other)						
	Downy mild. (Oomycota)					X	
	Phytophthora (Oomycota)				X		
	Nematodes			X			

	Forage	Small grains	Field crops	Fruits & Nuts	Forest & Landscape	Veggies	Orna-mentals
Viruses	X	X	X	X	X	X	X
Bacteria	X	X	X	X	X	X	X
Fungi (Rusts)	X	X	X	X	X	X	X
Fungi (Other)	X	X	X	X	X	X	X
Downy mild. (Oomycota)	X	X	X	X	X	X	X
Phytophthora (Oomycota)	X	X	X	X	X	X	X
Nematodes	X	X	X	X	X	X	X

	Forage	Small grains	Field crops	Fruits & Nuts	Forest & Landscape	Veggies	Orna-mentals				
Viruses		Forage crops	Small grains	Field crops	Fruits & Nuts	Forest & Landscape	Veggies	Orna-mentals			
Bacteria											
	Foliar		Forage crops	Small grains	Field crops	Fruits & Nuts	Forest & Landscape	Veggies	Orna-mentals		
Fungi (Rusts)	Root rots	Wind dispersed		Hay	Alfalfa	Corn	Wheat	Rice	Soybean	Pulse crops	
Fungi (Other)	Vascular wilts	Wind / rain dispersed	Viruses		Ornament	Green-house	Citrus	Fruits & Nuts	Forest & Land-scape	Veggies	Berries
Downy mild (Oomycota)	Seed rots	Seed-borne	Bacteria	Viruses							
Phytophthora (Oomycota)	Fruit rots	Vector-borne	Fungi (Rusts)	Bacteria							
	Rusts	Soilborne	Fungi (Other)	Fungi (Rusts)							
	Mildews	Over-seasoning	Downy mild. (Oomycota)	Fungi (Other)							
			Phytophthora (Oomycota)	Downy mild. (Oomycota)							
			Nematodes	Phytophthora (Oomycota)							
				Nematodes							

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- 2nd NPDRS Workshop – April 2007 (St. Louis, MO)
 - How to prioritize plant diseases for the NPDRS
(The concept of generic plans – ‘the Martyn Method’)



Research

Office of Pest Management Policy National Plant Disease Recovery System

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Plant Diseases That Threaten U.S. Agriculture

Identified and Prepared For Under the

National Plant Disease Recovery System

The National Plant Disease Recovery System

<http://www.ars.usda.gov/research/docs.htm?docid=14271>

“Two overriding concerns of the program discussed at our annual workshops are how to deal with the thousands of documented exotic diseases that may enter the United States and how to prepare for diseases that are yet unknown? **We believe that the solution is the Martyn Method. Simply put, the Martyn Method prepares for all diseases by developing a core group of recovery plans that represent every type of pathogen that could arrive or develop.** When an unexpected pathogen does arrive or emerge, one of the representative plans is used as a model to quickly assemble a new recovery plan for the unexpected pathogen.”

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- 4th NPDRS Workshop – March 2011 (Dallas, TX)
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Criteria for prioritization

- USDA Select agent and toxins list ✓
- Economic value of host crop
- Type of pathogen (Taxa)
- Type of host (crop)
- Type of host x type of pathogen matrix
- Pathogen epidemiology (dissemination / survival)
- Risk or threat factor
- Management strategy and epidemiology (Principles of disease management)

The Generic Cluster Concept

- Do plant diseases cluster around a set of epidemiological parameters that dictate similar response and management strategies?

Detection  Response  Mitigation & Mgt.  Recovery

Response and Recovery

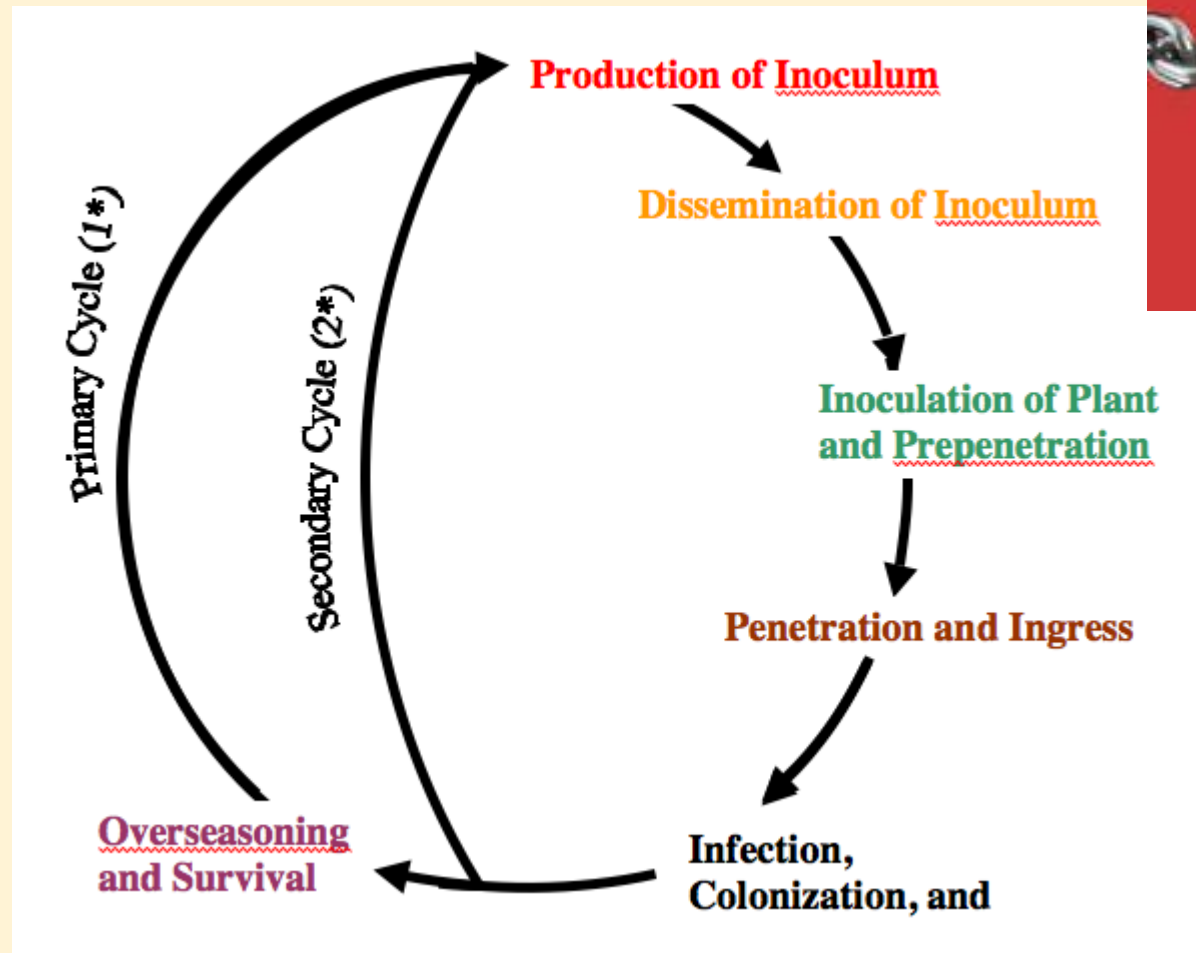
- How does it spread, survive, infect, reproduce, etc.
 - Quarantine vs. Monitoring & Surveillance
 - Eradication vs. Management

Principles of Plant Disease Management¹

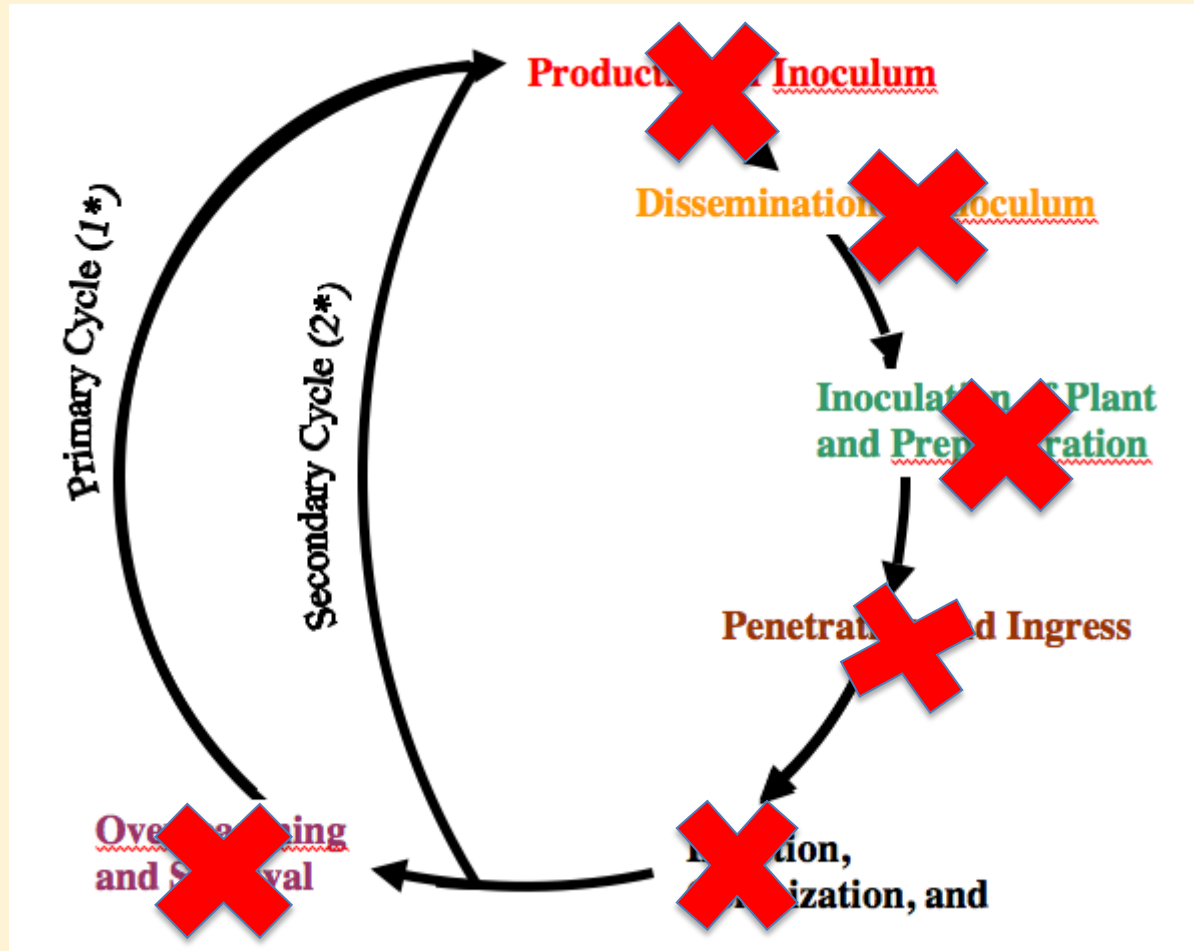
1. Exclusion
2. Eradication
3. Protection
4. Resistance
5. Therapy
6. Avoidance

¹National Academy of Sciences. 1968. Principles of Plant and Animal Pest Control. Vol 1. Plant Disease Development and Control. NAS Publ. #1596. Washington, D.C. 205 pp.

The Disease Cycle



The Disease Cycle



Where to Begin?

- Critically examine the current plant disease recovery plans for epidemiological, response and management strategies.

14 Completed Plant Disease Recovery Plans

- Citrus variegated chlorosis
- Citrus greening
- Downy mildews of corn
- Late wilt of corn
- Red leaf blotch of soybean
- Laurel wilt of redbay
- Laurel wilt of avocado
- Plum pox
- Potato wart
- Ralstonia bacterial wilt
- Rathyibacter poisoning
- Scots pine blister rust
- Stem rust of wheat (Ug99)
- *P. kernoviae* tree / shrub diseases

Recovery plan matrix by response and mitigation strategy

Dis. 11		Dis. 1	Dis. 2	Dis. 3	Dis. 4	Dis. 5	Dis. 6	Dis. 7	Dis. 8	Dis. 9	Dis. 10
	Educ. program										
	Survey & monitor										
	Plant test. & inspec.										
	Eval / devel resistance										
	Establish quarantine										
	Destruction host mat.										
	Likelihood early detec										
	Eradication poss. / prob										
	Chem. ctrl. practical										
	Vector ctrl. practical										
	Comp. to growers / homeowner										

PLANT DISEASE RECOVERY PLANS

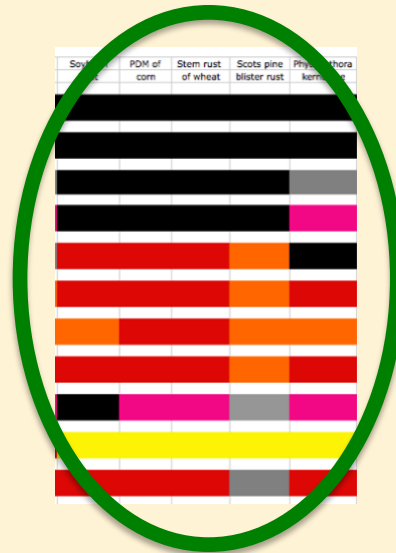
	Potato wart	Citrus var chlor (CVC)	Citrus green-ing (HLB)	Rathyibacter toxicus	Plum pox	RL blotch of soybean	Ralstonia bact wilt (R3b2)	Late wilt of corn	Soybean Rust	PDM of corn	Stem rust of wheat	Scots pine blister rust	Laurel wilt of red bay	Phytophthora kernoviae
Establish educ. program	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black
Establish survey monitor spread	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black
Plant inspections & testing	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Grey	Grey
Evaluate/develop resistance	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Pink
Establish quarantines, etc	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black
Destruction of host material	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black
Likelihood of early detection	Black	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange
Eradication possible / likely	Black	Red	Red	Red	Red	Red	Black	Grey	Red	Red	Red	Red	Red	Red
Chem. control (fungicides, etc.	Red	Red	Red	Red	Red	Black	Red	Pink	Black	Pink	Pink	Grey	Pink	Pink
Vector control practical	Yellow	Red	Red	Red	Red	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Red	Yellow
Comp. to growers/home	Grey	Black	Black	Black	Black	Red	Grey	Red	Red	Red	Red	Red	Red	Red
Legend	YES		QUESTIONABLE		NO		LIMITED		NOT FEASIBLE		NOT APPLIC			

	Potato wart	Citrus var-chlor (CVC)	Citrus green-ing (HLB)	Rathyibacter toxicus	Plum po	L. blotch soybean	Ralstonia bact wilt (R3b2)	Late wilt of corn	Soybean Rust	PDM of corn	Stem rust of wheat	Scots pine blister rust	Laurel wilt of red bay	Phytophthora kernoviae	Grapevine black foot	Potato yellow-ing virus	FW date palm
Establish educ. program	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Establish survey monitor spread	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Plant inspections & testing	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	QUESTIONABLE	QUESTIONABLE	NO	NO	NO
Evaluate/develop resistance	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NOT FEASIBLE	NOT FEASIBLE	NO	NO	NO
Establish quarantines, etc	NO	NO	NO	NO	NO	NO	QUESTIONABLE	QUESTIONABLE	NOT FEASIBLE	NOT FEASIBLE	NOT FEASIBLE	NOT FEASIBLE	QUESTIONABLE	QUESTIONABLE	NO	NO	NO
Destruction of host material	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Likelihood of early detection	NO	LIMITED	LIMITED	LIMITED	LIMITED	NO	LIMITED	LIMITED	LIMITED	LIMITED	LIMITED	LIMITED	LIMITED	LIMITED	NO	QUESTIONABLE	NO
Eradication possible / likely	NO	NO	NO	NO	NO	NO	NO	QUESTIONABLE	NO	NO	NO	NO	NO	NO	NO	NO	NO
Chem. control (fungicides, etc.	NO	NO	NO	NO	NO	NO	NO	NOT FEASIBLE	NOT FEASIBLE	NOT FEASIBLE	NOT FEASIBLE	QUESTIONABLE	NOT FEASIBLE	NOT FEASIBLE	NO	NO	NO
Vector control practical	LIMITED	NO	NO	NO	NO	LIMITED	LIMITED	LIMITED	LIMITED	LIMITED	LIMITED	LIMITED	NO	LIMITED	LIMITED	LIMITED	LIMITED
Comp. to growers/home	QUESTIONABLE	NO	NO	NO	NO	NO	QUESTIONABLE	NO	NO	NO	NO	QUESTIONABLE	NO	NO	NO	NO	NO
Legend	YES	QUESTIONABLE			NO	LIMITED		NOT FEASIBLE		NOT APPLIC							

Control principle

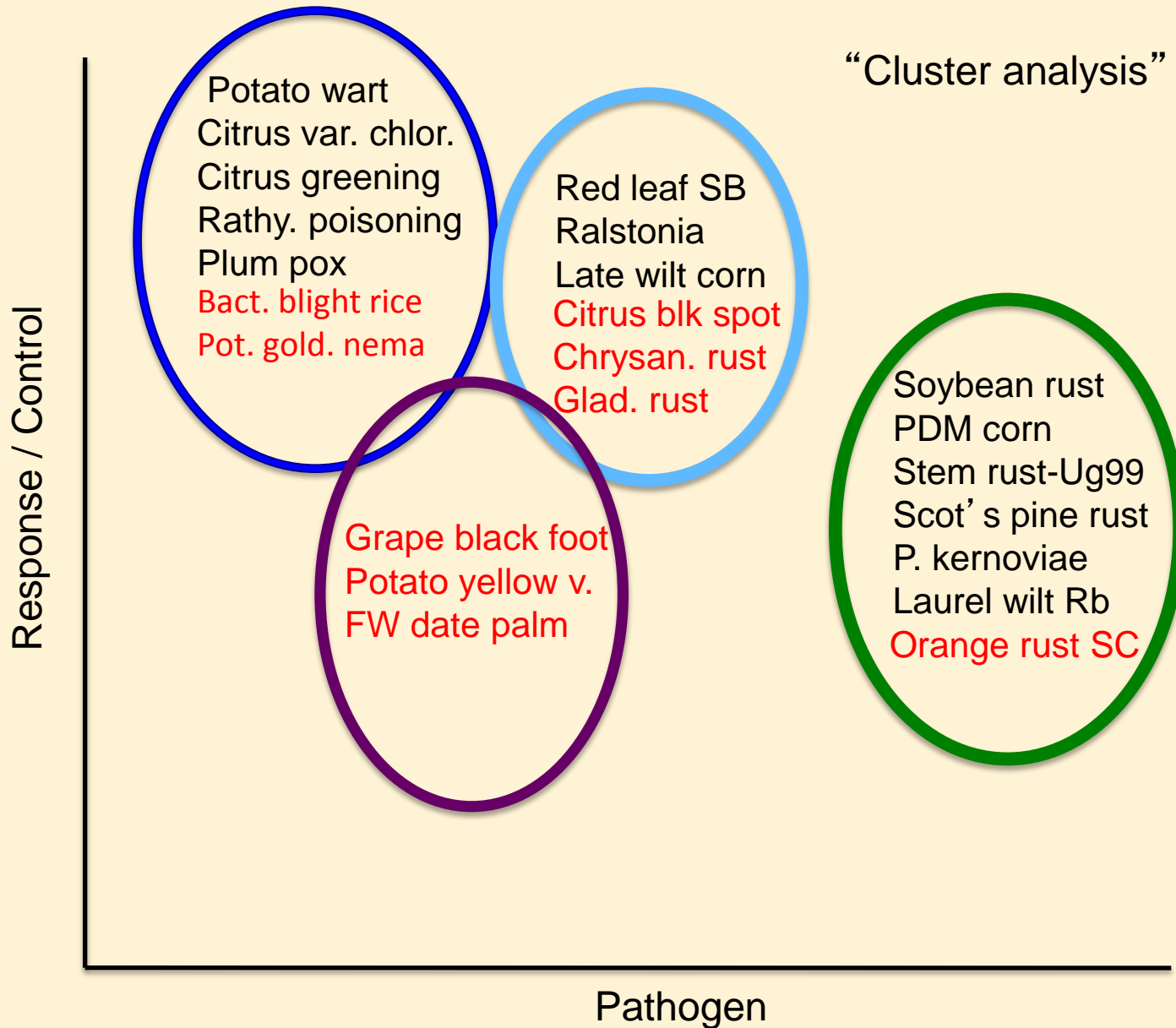


“Cluster analysis”



Plant disease

“Cluster analysis”



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- 5th NPDRS Workshop – April 2013 (Falls Church, VA)
 - Refining the model for generic recovery plans (**Are we getting closer to generic plans?**)



The Process

1. Can we take the 'cluster model concept' and apply metrics instead of 'color coding'?
2. What are the parameters / descriptors that are most important for discriminating between diseases (grouping or separating diseases)?
3. Can the model be validated statistically?
4. Can it be improved and how?

Process and Steps

- Several conference calls
- 1 ½ day project meeting in Dallas (Jun 2011)
 - Developed a set of descriptors that could be used to “score” each disease (yes or no)
 - List was intentionally long (75 individual descriptors)
 - Each project member (except one) reviewed each of the 14 current plant disease recovery plans and scored them for all 75 descriptors.

Method of Dissemination

BIOLOGY	
Method of dissemination / dispersal	
Null	
Wind	
Water	
Rain	
Seed/ plant parts	
Vector (biotic) – arthropod, fungal, nematode, other	
Circulative (not propagative, passes through insect without replication, transmitted for the life of the vector)	
	Semi-persistent
	Non-persistent
Fomite – human clothing, trade, travel, tools, equipmen, etc.	
Soil	

Method of Survival

Method of overseasoning and survival (survival beyond season of introduction of outbreak)
--

Null

Resting structures

In planta (living plant or plant part)
--

In soil saprophytically

In soil

In water

In vector

Fomite - human, equipment, pots

Alternate host overseasoning

Type of Disease Cycle

Type of disease cycle
Monocyclic
Polycyclic
Polyetic (monocyclic w/in a season, but appears polycyclic over multiple seasons)
Vector transmission
Non-persistent (older stylet-borne nature)
Semi-persistent
Circulative (pathogen circulates through the insect gut)
Propagative (pathogen reproduces within the vector)
Transovarial (pathogen is transferred to the vector offspring)

Host Range and Ecosystem

Pathogen reproductive potential
Low / Medium
Medium / High
Host range / specificity (many hosts or only one or a few)
Narrow – Single species or genus host
Moderate –multiple genera, same family
Broad – multiple plant families
Geospatial pattern of host plant
Contiguous
Fragmented (random)
Site type (area at risk vs outbreak?)
Agricultural field
Orchard/vineyard
Natural landscape
Forest
Residential
Planting stock production facility
Retail outlet
Greenhouse production (plants grown under shade cloth, plastic or glass)
Commercial nursery

Symptom Expression

Latency period for symptom development (relative to host / detection method)
Unknown
Short (< 14 days)
Medium (15 days - 60 day)
Extended (61-365)
Long (1 or more years)

Disease Management Principles

Exclusion

Quarantine (Is a quarantine practical? e.g. Karnal bunt vs soybean rust!)

Surveillance and monitoring

Testing/certification program

Sanitation practices (Are sanitation practices practical? e.g. Citrus canker vs stem rust of wheat)

Vector management practical? Would it likely succeed or significantly slow the spread?

Eradication

Host destruction (e.g., burning, tillage, rouging, alternate host destruction)

Fumigation / pesticide/ pheromone confusion / sterile vector/pest release

Host and / or pathogen free period/ restricted planting (fallow)

Seed / propagative plant part treatment

Residue / soil treatment management (tillage, liming, flooding, etc.)

Vector management likely to succeed?

Disease Management Principles

Protection (protective fungicides, insecticides)

Known efficacious protective treatments exist

Effective chemistries exist but not labeled

Not known if efficacious protective treatments exist

Efficacious protective treatments exist but not feasible or practical

Protection not feasible regardless

Resistance

Resistance exists

Resistance is known but not available

Resistance is not currently known / evaluation of germplasm

Begin a race-specific breeding program

Avoidance (Is it practical to practice avoidance strategies?)

Yes

No

Public / Social Impact

Public / Social Impact
Is crop insurance available?
Yes
No
Would there likely be public assistance / grower compensation available?
Yes
No
Would an emergency declaration be a likely action?
Yes
No
Length of recovery from significant outbreak?
Short
Long
Would there be a significant trade impact
High
Low
Is there a relevance to food safety?
Yes
No
Is there a relevance to food security?
Yes
No
What is the potential economic damage - Private/Commercial incl. loss of profit/cost of response/ loss of trade
High
Low
Would economic damage to the public be likely? e.g., tax payer cost response e.g., citrus canker?
High
Low
Would a social impact be likely? / public response? e.g. citrus canker?
Low
High

Process and Steps (con't)

- Project meeting at APS annual meeting in Hawaii (Aug 2011)
 - Neil M^cRoberts joined the group.
 - Data from the initial scoring for each evaluator was compiled.
 - Converted “yes / no” responses to “0 / 1”
 - Dropped some descriptors.
 - A preliminary principal component analysis (PCA) performed on the data; evidence of clustering
 - Conference calls to discuss analysis.

Process and Steps (con't)

- Project meeting at APS annual meeting in Providence, RI (Aug 2012)
 - Each project member was asked to re-evaluate and revise the descriptor list individually; eliminate those that were redundant, ambiguous, and/or irrelevant and reduce the # descriptors.
 - Descriptors reduced from 75 to 35.
 - Principal component analysis performed on the revised (reduced) list of descriptors.

Questions Asked

- Are there diseases that cluster based on epidemiological and management parameters?
- Is there inter-rater agreement among evaluators?

What did these exercises tell us?

- Conceptually plant diseases do cluster around common aspects of their biology and epidemiology and the principles of plant disease management – even diseases that on the surface might be considered quite different.
- Knowledgeable raters can agree, within reason, and consistently rate in a similar manner.
- More refinement may be needed in the descriptors
- But

The 'devil is in the details'.

