Anticipatory Breeding for Phytophthora Blight Resistance in Chile Pepper

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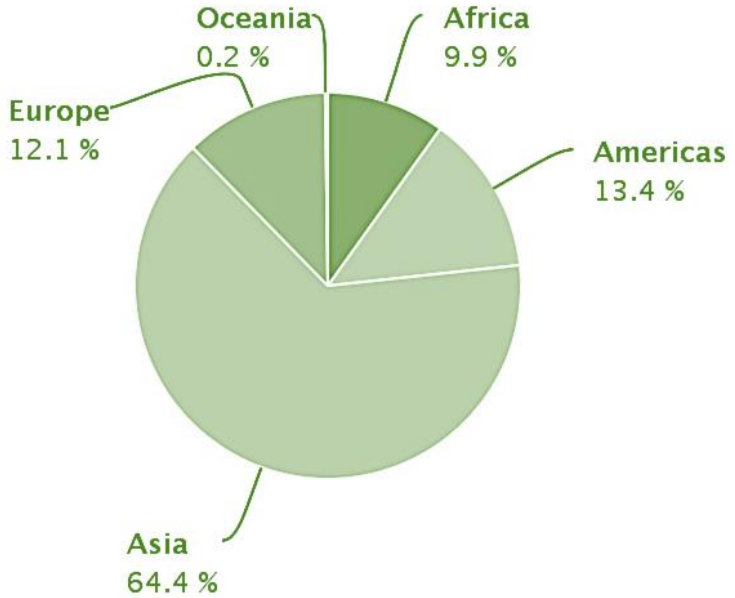
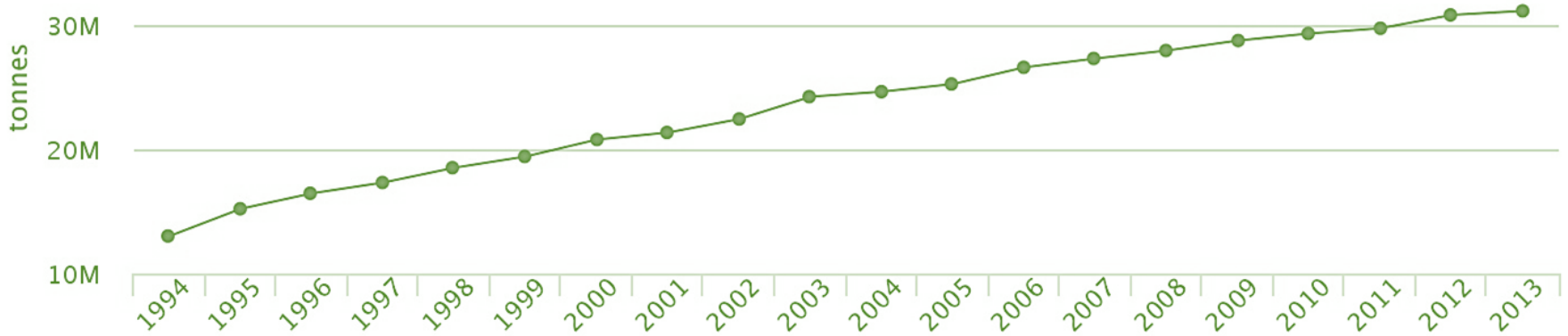
Chile pepper background

- Grown and consumed around the world
  - Prized for capsaicinoid content
- Economically important for smallholder farmers
- Significant source of important nutrients
  - Vitamin C
  - Vitamin A





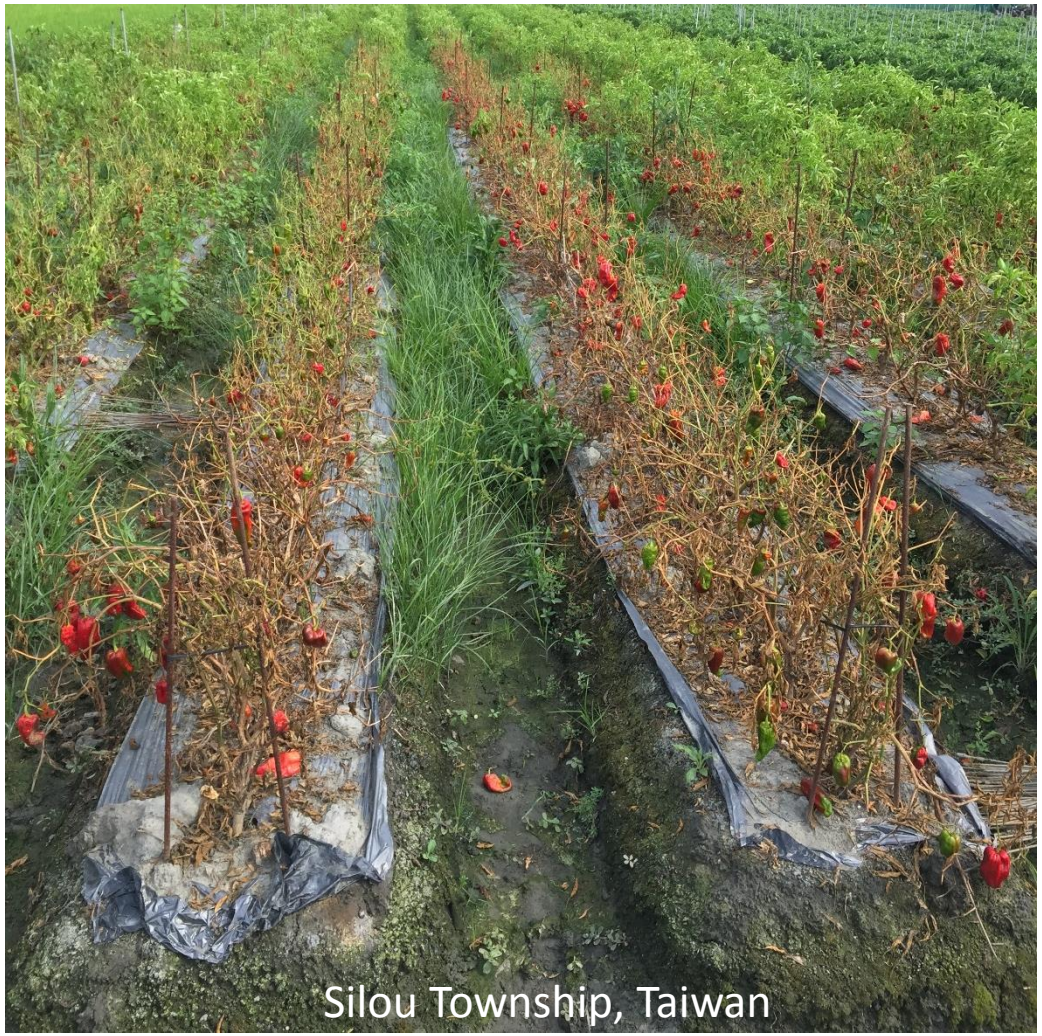
FAO, 2014

Phytophthora capsici background

- One of the most devastating pathogens
  - ≈$100 million in losses annually
- Management strategies
  - Irrigation management
  - Crop rotation
  - Soil solarization
  - Fungicide applications
  - Resistant cultivars

Resistant cultivars

- Multiple disease syndromes
  - Root rot
  - Stem blight
  - Foliar blight
  - Fruit rot
- Multiple physiological races
  - Coevolution
    - Gene-for-gene
  - A1 and A2 mating types
  - Mutation



Anticipatory breeding

- Described by McIntosh (1992) and McIntosh and Brown (1997)
- Technique of breeding for resistance to virulent pathogen races before they become prevalent and cause significant losses.
  - Requirements
    - Knowledge of pathogen epidemiology
    - Regular pathogen surveys aimed at detecting new races that have the potential to overcome current *R* genes
    - Knowledge of primary *R* genes in current cultivars
    - Well-coordinated system of screening, for identifying sources of resistance.

Race detection

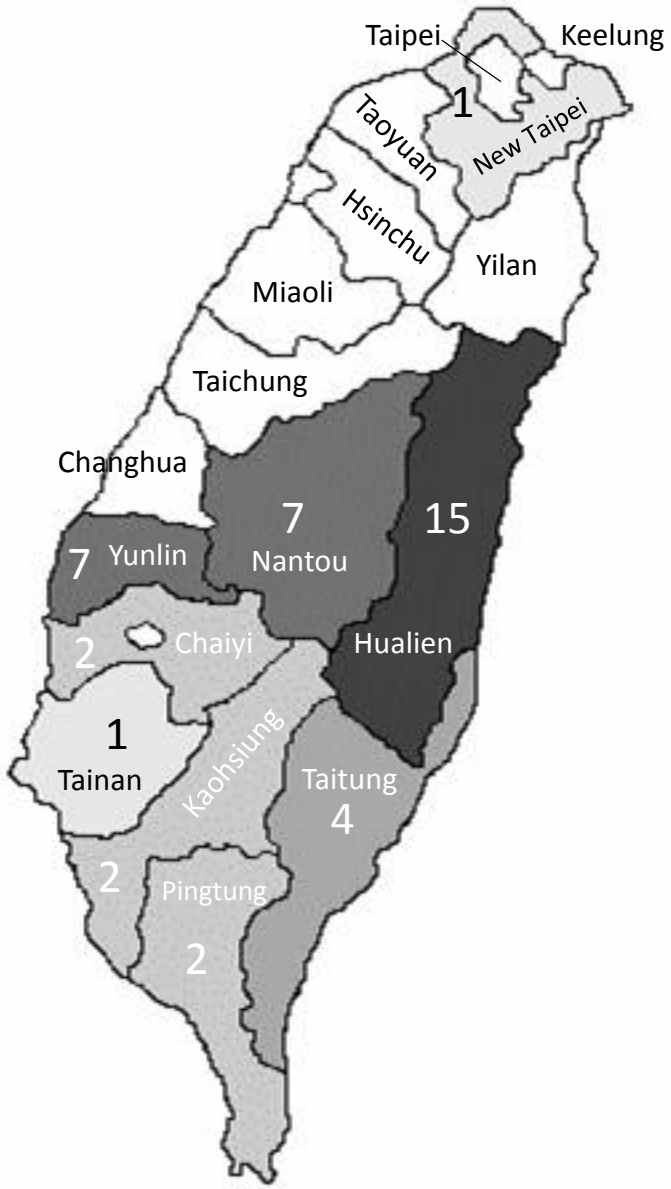
- Host differential
  - Comprised of lines or cultivars of a host that have one or more resistance genes to a pathogen.
  - McIntosh used wheat cultivars, but this cannot be done in chile pepper
- Recombinant inbred lines (RIL)
  - Advantages
    - Combining maximum genetic variability within the population with homozygous genotypes
    - Can be replicated permanently without risk of segregation
  - Disadvantages
    - Expensive
    - Time consuming to develop
    - Parental selection can be difficult

Justification

Race	Oelke et al. (2003)	Sy et al. (2008)	Glosier et al. (2008)	Lee et al. (2010)	The World Vegetable Center
			Origin		
1	USA-NM	USA-NM	USA-CA	Korea	Taiwan
2	Turkey	USA-NM	USA-CA	Korea	Taiwan
3	Turkey	Netherlands	USA-NC	Korea	Taiwan
4	USA-NM	USA-NM	USA-CA	Korea	
5	Italy	USA-NM	USA-CA	Korea	
6	USA-NJ	USA-NM	USA-CA	Korea	
7	USA-NJ	USA-NM	USA-CA	Korea	
8	Korea	USA-NM	USA-CA	Korea	
9	USA-NJ	USA-NM	USA-CA	Korea	
10		USA-NM	USA-CA	Korea	
11		USA-NM	USA-CA	Korea	
12		USA-NM	USA-CA		
13		USA-CA	USA-CA		

Materials and Methods

- 38 *P. capsici* isolates were collected in 2016
  - South and central Taiwan
- Host Differential
  - 18 New Mexico Recombinant Inbred Lines (NMRILs)
    - F_8 lines derived from 'Early Jalapeno' x CM-334



Standardized 10 point scale for scoring disease severity.

- 10,000 zoospores•plant^{-1}
- Plants were scored after ≈2 weeks
- Only those with average scores of ≤1 were resistant

Photograph taken by Yan Ji Teoh

NMRIL Disease Reactions

	378	374	376	3	379	2	381	383	375	385	380	398	377	373	393	1	395	389	382	384	396	388	391	392	413	390	397
CM334	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
NMRIL-P	R	R	R	S	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
NMRIL-O	R	R	R	R	S	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	S	R	R	R	R
NMRIL-H	S	R	R	R	R	R	R	R	R	S	R	R	R	R	R	S	R	R	S	R	R	R	R	R	R	R	R
NMRIL-N	S	R	R	R	R	R	R	R	S	R	R	S	R	R	R	S	R	R	R	R	R	R	R	R	R	R	R
NMRIL-X	R	R	S	R	R	R	S	S	R	R	S	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
NMRIL-AE	S	S	R	R	S	R	R	R	S	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	S	R	R
NMRIL-F	R	S	R	S	S	S	S	R	R	R	R	R	S	S	R	R	R	S	S	R	S	S	R	R	R	R	R
NMRIL-B	S	S	S	R	S	S	S	S	R	S	S	R	R	R	R	R	S	R	R	R	R	R	S	R	S	R	R
NMRIL-Z	S	R	S	S	S	S	R	S	S	S	S	R	R	R	S	S	R	R	R	S	R	S	R	R	R	R	R
NMRIL-E	S	S	S	S	R	S	R	R	S	R	S	S	S	S	S	R	R	S	R	R	R	S	R	R	S	R	R
NMRIL-I	S	S	S	S	R	S	S	S	S	S	R	S	S	R	R	R	S	R	S	R	R	R	S	R	R	R	R
NMRIL-G	S	S	S	S	S	R	S	S	R	R	S	S	S	S	S	R	S	R	S	S	R	R	R	R	R	R	R
NMRIL-AA	S	S	S	S	S	S	S	S	S	S	S	S	S	R	S	R	S	R	R	R	S	R	R	R	R	R	S
NMRIL-AD	S	S	S	S	S	S	S	S	S	S	S	R	S	S	S	R	R	R	R	R	S	R	S	R	R	R	S
NMRIL-M	S	S	S	S	S	S	S	S	R	S	S	S	S	S	S	S	R	S	R	S	R	R	R	R	R	S	R
NMRIL-A	S	S	S	S	S	S	S	S	S	S	R	S	R	S	S	S	R	S	S	S	S	S	S	S	R	R	R
NMRIL-R	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	R	R	S	R	S	R	R	R
NMRIL-S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	R	S	S	S	R	S	S	R	R	S	R	S	R
NMCA10399	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S

Subset Host Differentials

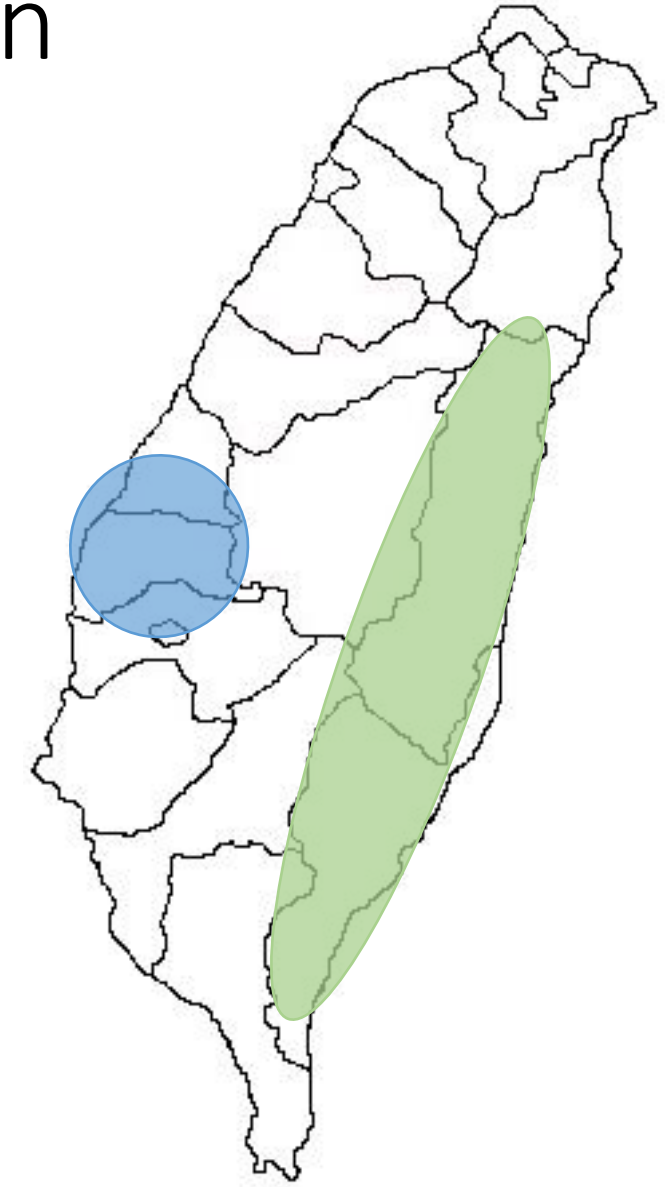
	378	374	376	3	2	379	383	380	377	381	398	393	385	375	395	384	373	389	1	382	396	388	413	391	390	397	392
NMRIL-AE	S	S	R	R	R	S	R	R	R	R	R	R	R	S	R	R	R	R	R	R	R	R	S	R	R	R	R
NMRIL-F	R	S	R	S	S	S	R	R	S	S	R	R	R	R	R	R	S	S	R	S	S	S	R	R	R	R	R
NMRIL-B	S	S	S	R	S	S	S	S	R	S	R	R	S	R	S	R	R	R	R	R	R	R	S	S	R	R	R
NMRIL-Z	S	R	S	S	S	S	S	S	R	R	R	S	S	S	R	S	R	R	S	R	R	S	R	R	R	R	R
NMRIL-E	S	S	S	S	S	R	R	S	S	R	S	S	R	S	R	R	S	S	R	R	R	S	S	R	R	R	R
NMRIL-I	S	S	S	S	S	R	S	R	S	S	S	R	S	S	S	R	R	R	R	S	R	R	R	S	R	R	R
NMRIL-G	S	S	S	S	R	S	S	S	S	S	S	S	R	R	S	S	S	R	R	S	R	R	R	R	R	R	R
NMRIL-AA	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	R	R	R	R	R	S	R	R	R	R	S	R
NMRIL-M	S	S	S	S	S	S	S	S	S	S	S	S	S	R	R	S	S	S	S	R	R	R	R	R	S	R	R
NMRIL-S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	R	S	S	R	S	R	R	R	S	R	S

Unweighted Pair Group Method with Arithmetic Mean Analysis (UPGMA)

	1													2												
	378	374	376	3	2	379	383	380	377	381	398	385	375	393	395	384	373	389	1	382	396	388	413	391	390	397	392
NMRIL-AE	S	S	R	R	R	S	R	R	R	R	R	R	S	R	R	R	R	R	R	R	R	R	S	R	R	R	R
NMRIL-F	R	S	R	S	S	S	R	R	S	S	R	R	R	R	R	R	S	S	R	S	S	S	R	R	R	R	R
NMRIL-B	S	S	S	R	S	S	S	S	R	S	R	S	R	R	S	R	R	R	R	R	R	R	S	S	R	R	R
NMRIL-Z	S	R	S	S	S	S	S	S	R	R	R	S	S	S	R	S	R	R	S	R	R	S	R	R	R	R	R
NMRIL-E	S	S	S	S	S	R	R	S	S	R	S	R	S	S	R	R	S	S	R	R	R	S	S	R	R	R	R
NMRIL-I	S	S	S	S	S	R	S	R	S	S	S	S	S	R	S	R	R	R	R	S	R	R	R	S	R	R	R
NMRIL-G	S	S	S	S	R	S	S	S	S	S	S	R	R	S	S	S	S	R	R	S	R	R	R	R	R	R	R
NMRIL-AA	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	R	R	R	R	R	S	R	R	R	R	S	R
NMRIL-M	S	S	S	S	S	S	S	S	S	S	S	S	R	S	R	S	S	S	S	R	R	R	R	R	S	R	R
NMRIL-S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	R	S	S	R	S	R	R	R	S	R	S

Cluster Distribution

Cluster 1 was primarily in Yunlin county on the west coast



Cluster 2 was primarily on the east coast in Hualien and Taitung counties

Conclusions

- Race characterization
  - 27 races on the island
  - Taiwan subset = 2^{10} = 1,024 races
  - Practicality for local breeding
    - Two major clusters
      - Virulence varied by coast
    - Implications for anticipatory breeding
      - Gene deployment

Outlook

- Universal race characterization system is possible
  - Implementation in other countries
    - Indonesia
    - India
  - Preliminary tests are required to determine which NMRILs will work

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Thank you