

Clubroot Pathotypes

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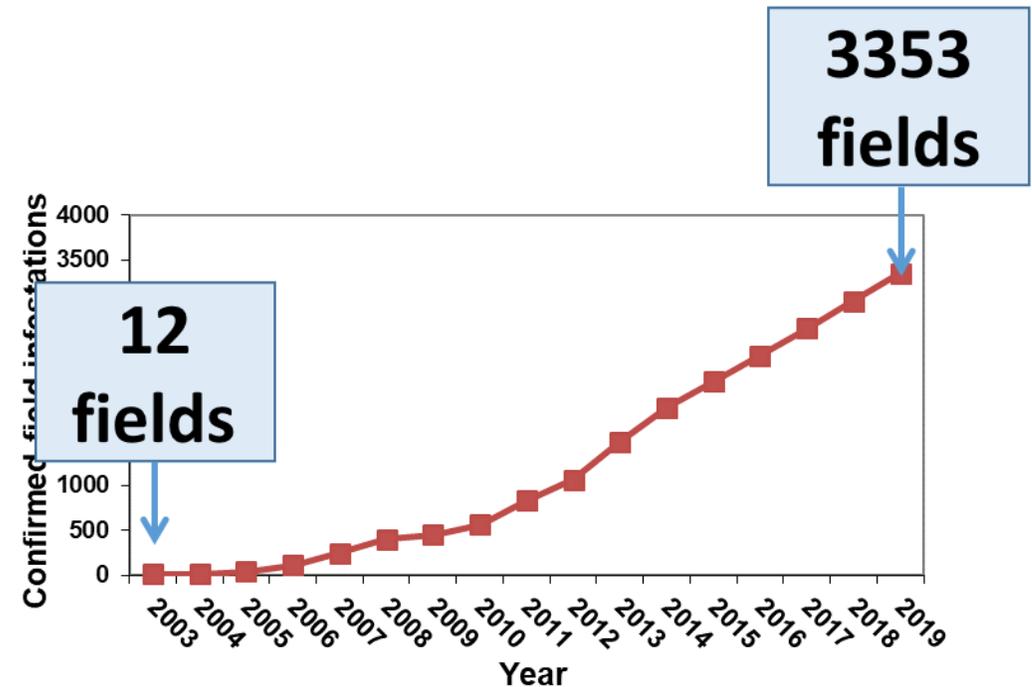
Clubroot Steering Committee Meeting

April 30th 2020



History of Clubroot in AB

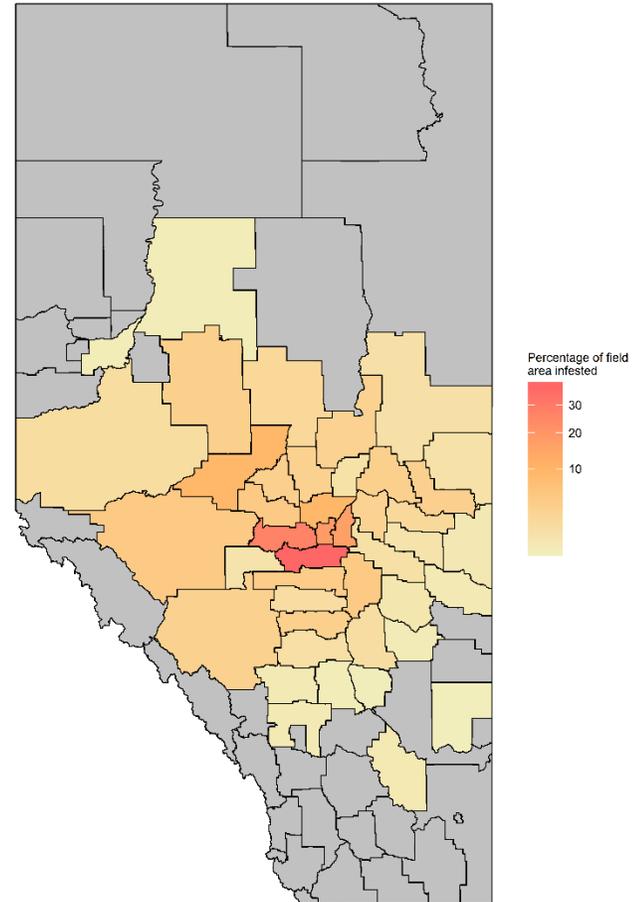
- Isolated cases reported in home and market gardens (1970s – 2001)
- First cases on canola identified in 2003 (12 fields near Edmonton, AB)
- Rapid increase in confirmed infestations in subsequent years (2005-2019)



Clubroot Situation

- Clubroot continues to spread
 - First cases in Kneehill & Starland (2019)
 - Total of 307 new confirmed infestations in 2019
- Some of most severely infested fields were planted to CR canola

Percentage of field area infested by clubroot in Alberta by county in 2019



Strelkov et al. unpublished

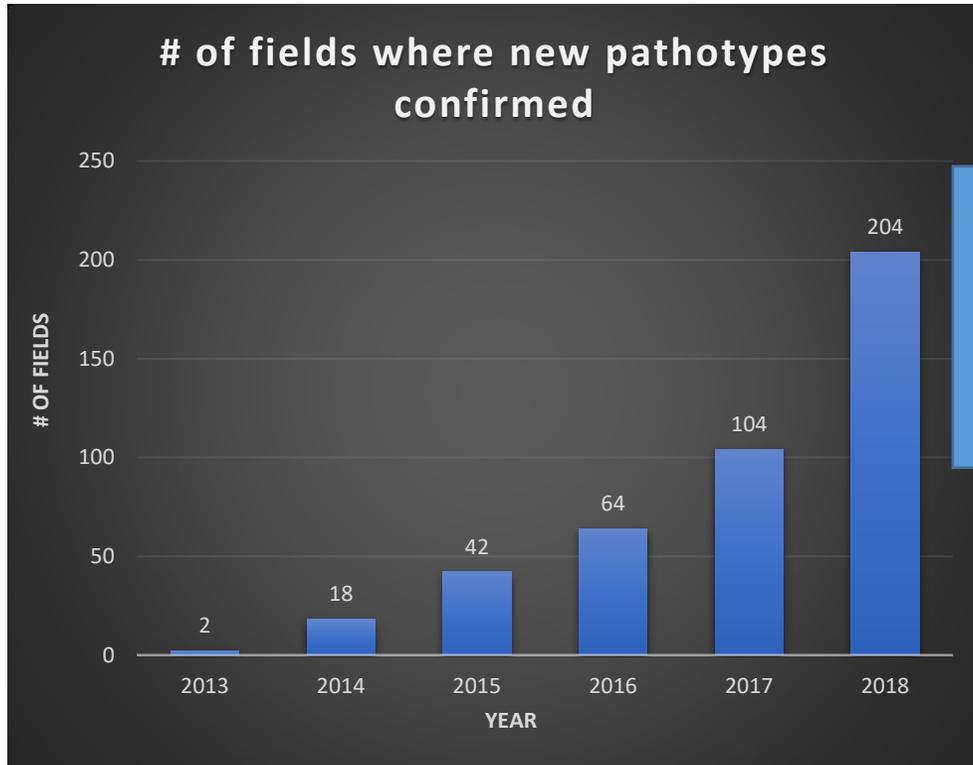
Clubroot in CR Canola

- Annual surveys have found increasing numbers of fields where resistance has been overcome
- Resistance has been overcome in Alberta and Manitoba, but so far not in Saskatchewan
- Samples from fields with resistance issues are further evaluated in the greenhouse for ability to overcome resistance and pathotype designation

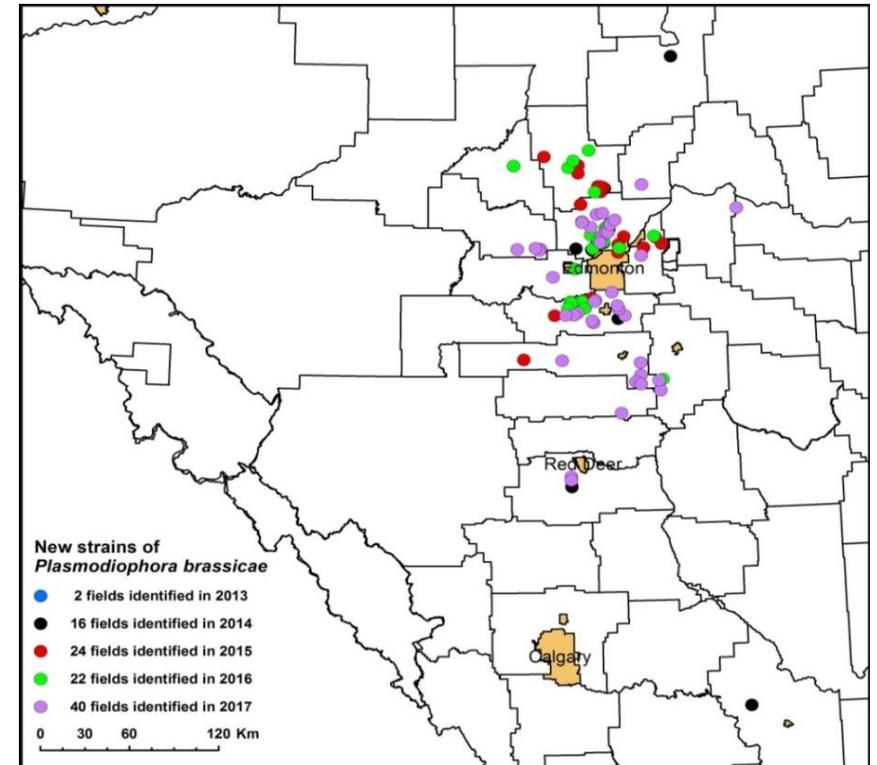


Clubroot Resistance Erosion

Increase in fields with resistance issues



+ 134 more potential cases in 2019



Strelkov et al. unpublished

Clubroot resistance breakdown in Alberta
Year: 2013



Challenge: Pathotype Identification

- “New” *P. brassicae* strains that overcome resistance cannot be distinguished from “old” strains based on commonly used pathotype classification systems
- Example: First of the new strains were classified as pathotype 5 on Williams’ differential set
 - But this classification did not reflect their virulence on CR canola

Pathotyping

- Long process typically taking several months to complete
- High demand for pathotyping from Agriculture Fieldmen, Agronomists, and Counties
- Important to determine spread of new pathotypes, as well as pathotype diversity
- Helps agronomists and land owners determine the best on farm management plan, as well as smart genetic deployment schedules

Canadian Clubroot Differential Set

- Populations from fields with resistance issues are tested for pathotype designation on the Canadian Clubroot Differential (CCD) Set
- Results from 2018 collections have been completed



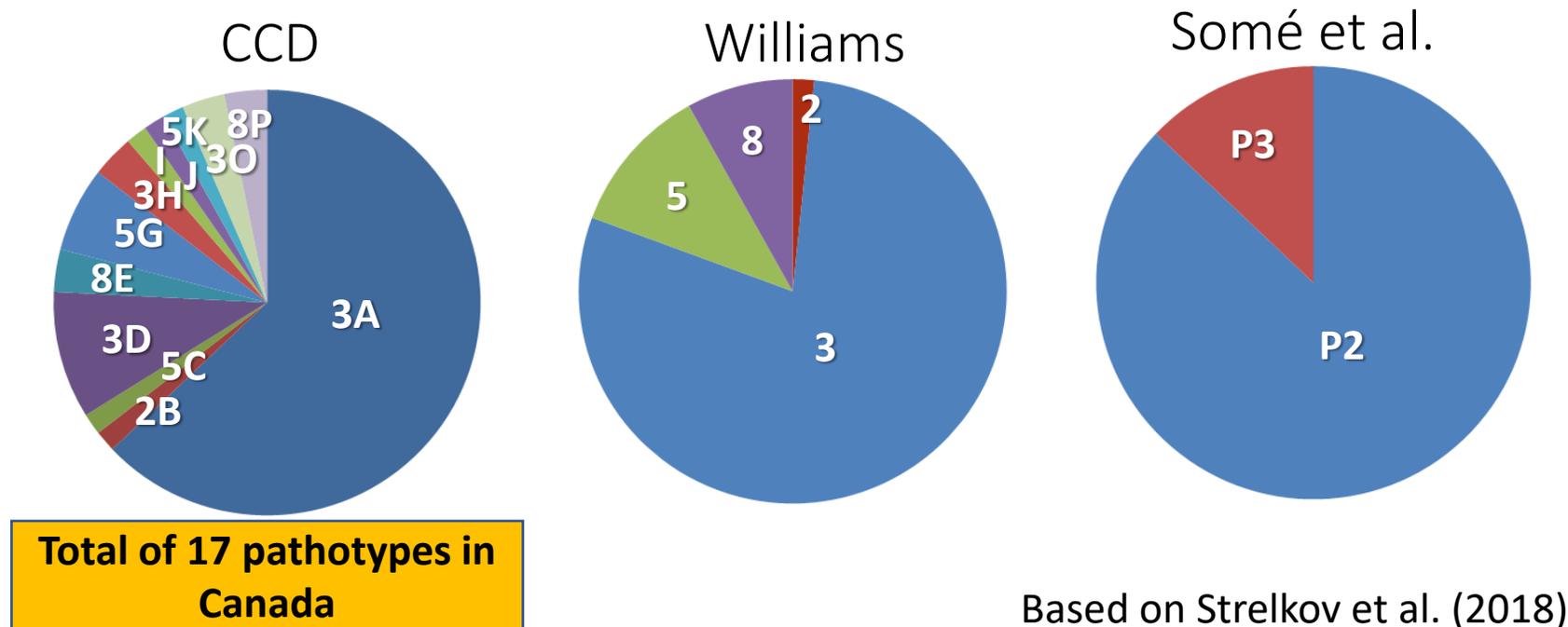
CCD Pathotype Classifications

Differential Host	Reaction																	
ECD 02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ECD 05	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
ECD 06	+	+	+	+	+	+	-	+	+	-	-	-	+	+	-	+	-	-
ECD 08	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+
ECD 09	+	+	+	+	+	+	-	+	+	-	-	-	+	+	+	+	+	-
ECD 10 W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ECD 11 BS	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
ECD 13 JQ	+	+	-	+	-	+	-	+	-	-	-	-	+	-	+	-	-	-
Brutor	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Laurentian	+	+	-	+	+	+	-	+	-	+	-	-	-	+	+	+	+	-
Mendel	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+
Westar	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
45H29	+	+	+	+	+	-	+	-	-	+	+	-	-	-	+	+	+	+
Pathotype designations																		
CCD	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	X	
Williams	3	2	5	3	8	2	5	3	5	8	5	5	6	8	3	8	5	
Somé et al.	P2	P2	P2	P2	P2	P2	P3	P2	P2	P3	P3	P3	P2	P2	P3	P2	P3	

- Unique virulence patterns assigned different letters to designate each pathotype (Strelkov et al. 2018)
- Also allows for pathotype designations to be obtained as per Williams (1966) & Somé et al. (1996)

Pathotypes Identified 2014-2016

- CCD Set has a good differentiating capacity
- Enabled identification of multiple distinct virulence phenotypes among pathogen populations able to overcome resistance



Current Pathotypes

Table 1. Pathotype Classification Scheme on the hosts of the Canadian Clubroot Differential Set

Pathotype designation ^{a,b}	A	B	C	F	A	D	H	O	A	G	I	K	L	X	A	B	C	D	M	A	A	B	C	D	E	J	N	P	A	B	C	A	A	B			
Williams	2	2	2	2	3	3	3	3	4	5	5	5	5	5	6	6	6	6	6	6	7	8	8	8	8	8	8	8	9	9	9	11	13	13			
Somé et al.	P ₂	P ₂	P ₃	P ₂	P ₂	P ₂	P ₂	P ₃	P ₃	P ₂	P ₃	P ₄	P ₂	P ₂	P ₁	P ₂	P ₁	P ₁	P ₂	P ₁	P ₂	P ₂	P ₁	P ₁	P ₅	P ₁	P ₅	P ₅									
Differential Host	Reaction																																				
ECD 02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
ECD 05	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
ECD 06 N	+	+	-	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
ECD 08	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
ECD 09	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
ECD 10 W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
ECD 11 JQ	+	+	+	+	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
ECD 13 BS	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
Brutor	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
Laurentian	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
Mendel	-	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
Westar	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
45H29	+	+	-	-	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

- Number of new pathotypes has continued to increase
- Several novel virulence patterns identified in ‘new’ clubroot regions and from single-spore isolates
- 36 unique pathotypes characterized to date

Challenge: Rapid identification of new pathotypes meant that we were running out of letters
Following consultation at “CLUB Day” industry meeting (Nov. 2019), we have modified pathotype nomenclature to streamline system

Revised CCD Nomenclature

Original system:

- Pathotypes assigned a letter in the order they were discovered
 - Each letter was used only once
- While they could also be assigned a number under Williams' system, this was not officially part of CCD designation

Revised system:

- Pathotype designations will include Williams' number first, followed by a letter
- Entire alphabet may be applied to distinguish multiple variants of a single Williams' pathotype

Example: pathotype 9 variants		
Old names		New name (combined)
Williams	CCD	
9	AA	9A
9	AB	9B
9	AH	9C

K. Hollman M.Sc. Thesis Work

Names of original pathotypes (Strelkov et al. 2018) will stay the same (3A, 5X...)

Pathotype Composition

- Nineteen pathotypes can overcome 1st generation resistance
 - 2A, 2B, 3A, 3D, 3O, 4A, 5C, 5G, 5K, 5X, 6A, 6B, 8C, 8E, 8J, 8P, 9A, 9B, 11A
- Seventeen do not overcome resistance
 - 2C, 2F, 3H, 5A, 5I, 5L, 6C, 6D, 6M, 7A, 8A, 8B, 8D, 8N, 9C, 13A, 13B

Table 1. Pathotype Classification Scheme on the hosts of the Canadian Clubroot Differential Set

Pathotype designation ^{a,b}	A	B	C	F	A	D	H	O	A	A	C	G	I	K	L	X	A	B	C	D	M	A	A	B	C	D	E	J	N	P	A	B	C	A	A	B	
Williams	2	2	2	2	3	3	3	3	4	5	5	5	5	5	5	5	6	6	6	6	6	7	8	8	8	8	8	8	8	9	9	9	9	11	13	13	
Somé et al.	P ₂	P ₂	P ₃	P ₂	P ₂	P ₃	P ₂	P ₂	P ₃	P ₂	P ₃	P ₃	P ₂	P ₃	P ₂																						
Differential Reaction																																					
ECD 02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
ECD 05	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
ECD 06 N	+	+	-	+	+	+	+	-	+	-	+	-	+	-	-	-	-	-	-	-	+	+	-	+	-	-	+	-	+	+	+	-	+	-	-	-	
ECD 08	+	+	-	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
ECD 09	+	+	-	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-	+	+	+	+	+	+	+	+	+	-	-	+	+	-	-	-	
ECD 10 W	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	+	-	-	
ECD 11 JQ	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
ECD 13 BS	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	
Brutor	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
Laurentian	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Mendel	-	+	-	-	+	-	-	-	+	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	+	-	+	+	-	+	-	-	
Westar	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
45k29	+	+	-	-	+	+	-	+	+	-	+	+	-	+	-	+	+	+	-	-	-	-	-	-	-	-	-	-	+	+	+	+	+	+	-	-	-

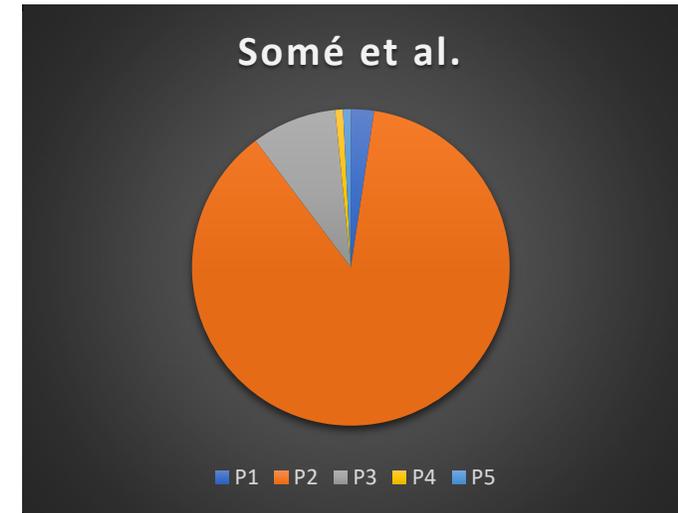
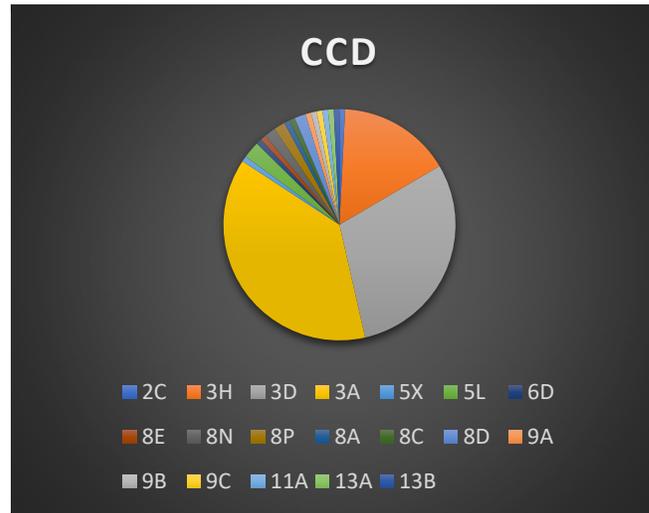
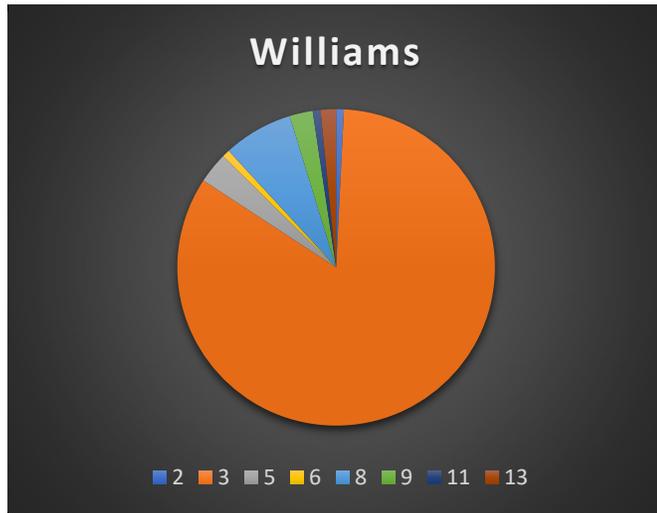
New Pathotypes

- Total of 9 new pathotypes identified from pathogen collections in 2017 and 2018
 - 6C, 8A, 9A, 9B, 6D, 13A, 8C, 8D, 11A
 - Demonstrated the diversity in pathogen virulence
 - Most of the 'new' pathotypes confined to a specific area/county

Clubroot resistance breakdown in Alberta
Year: 2013



Pathotypes Identified 2017 & 2018



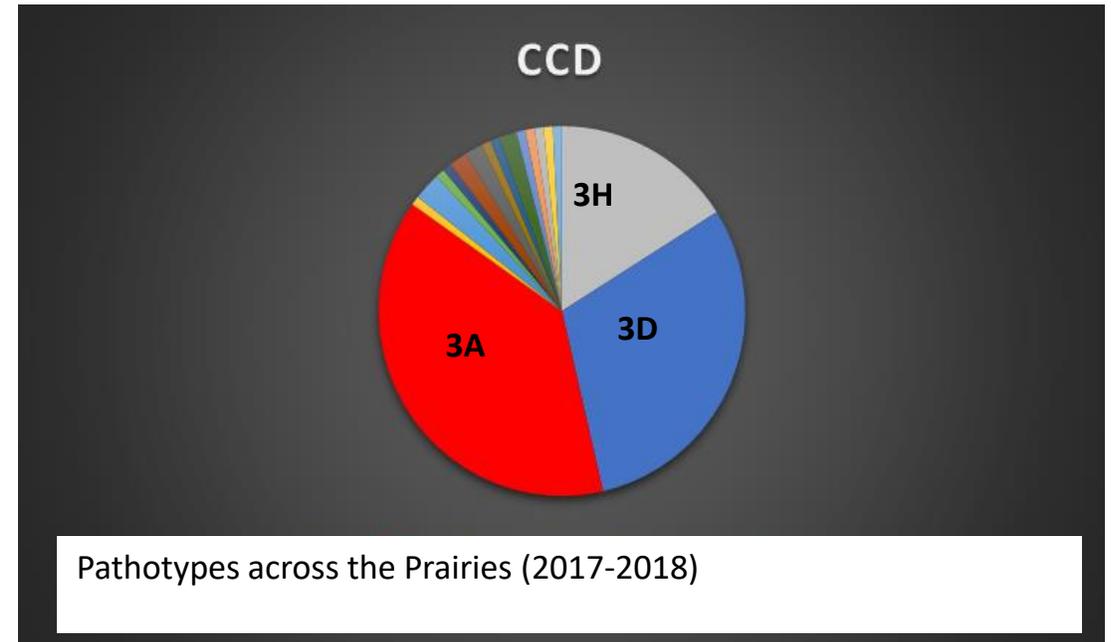
**Total of 36 pathotypes in
Canada as of 2018**

- More diversity in pathotypes discovered
- Continued increase in new pathotypes
- CCD designations help further identify a pathotypes unique virulence pattern in order to more accurately focus breeding efforts

**Despite the large number
of pathotypes, only a few
are common or widely
distributed**

Predominant Pathotypes

- Predominant pathotypes continue to be 3A, 3D and the 'old' pathotype 3H
- Most of the other 'new' pathotypes confined to specific areas/counties or identified only from single-spore isolates



Conclusions

- Clubroot continues to spread
- Biggest issue in established clubroot areas is emergence of new pathotypes
- With so many new pathotypes, breeders may have to make strategic decisions
 - Focus on predominant pathotypes
 - Genetics may not be an option for some farms with unique/rare pathotypes



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