

# Screening and evaluation of *Brassica* accessions for developing clubroot-resistant commercial canola varieties

Rudolph Fredua-Agyeman, Sheau-Fang Hwang and Stephen E. Strelkov



Department of Agricultural, Food and Nutritional Science,  
University of Alberta, Edmonton, AB, T6G 2P5, Canada.

# Overview

## ❑ Background:

- Clubroot of *Brassica* crops
- Clubroot resistance resources used for breeding CR canola cvs. in Canada
- Emergence of new isolates of *P. brassicae* able to overcome resistance

## ❑ Purpose of the research

- Search for new CR resources against ‘old’ and ‘new’ strains of the pathogen

## ❑ Results and discussions

## ❑ Conclusions

# Clubroot in Canada

## ➤ Cruciferous vegetable crops

- ***B. oleracea***: Kales (ssp. *acephala*), Brussels sprouts (ssp. *gemmifera*), cabbages (ssp. *capitata*), cauliflower (ssp. *botrytis*), broccoli (ssp. *italica*) and kohlrabi (ssp. *gongylodes*)
- ***B. rapa***: turnips (ssp. *rapifera*), Pak choi (ssp. *chinensis*) and Chinese Cabbage (ssp. *pekinensis*)

**Ontario, Quebec, British Columbia and Atlantic Provinces**

## ➤ Canola

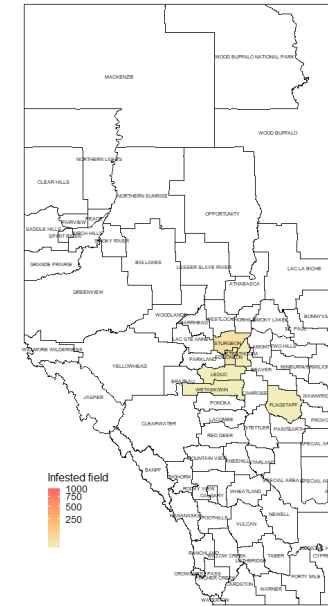
- ***B. napus*** L subsp. *napus*
- ***B. rapa*** subsp. *oleifera*
- ***B. juncea***

**Alberta, Saskatchewan and Manitoba**

RB infested field in Alberta by county  
Year: 2013



WT infested field in Alberta by county  
Year: 2005



Maps Courtesy of Dr. Yoann Aigu

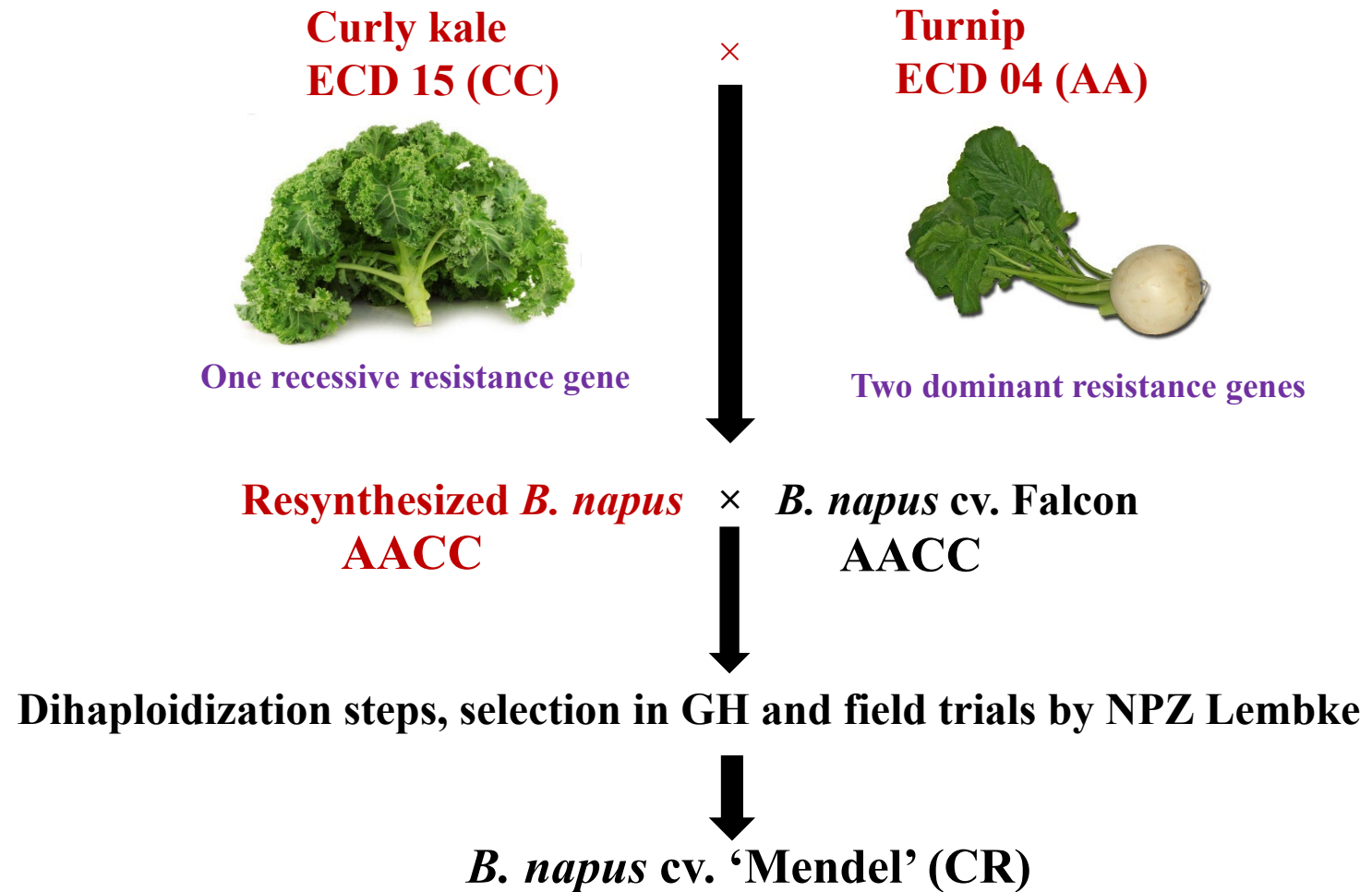
## Clubroot in Alberta

- **2003: 12 fields discovered near Edmonton, Alberta**
- **2009: Release of 'first generation' resistant cultivar '45H29'**
- **2013: First case of resistance breaking pathotypes**
- **2018: Release of 'second generation' resistant cultivars**
- **2022: 3894 infested fields**

# Clubroot-a devastating disease of *Brassica* crops

- **Average yield losses due to clubroot disease is estimated to be about 10-30%**
- **Total crop failure can occur in severely infected fields when susceptible hosts are grown**
- **This translates to a further \$1.2 billion or higher in revenue for Alberta**

# *Brassica napus* cv. 'Mendel' as a source of "1<sup>st</sup> generation" clubroot resistant genes



*References: Diederichsen and Sacristan 1996; Diederichsen et al. 2006, 2009*

# Rutabaga as a source of “2<sup>nd</sup> generation” clubroot resistant genes

- ❑ Public rutabaga breeding programs existed in Ontario, Quebec, Nova Scotia and Newfoundland in the 1950s and 1960s (*Spaner 2000*)
- ❑ **Five clubroot-resistant varieties were released in the Maritime provinces**

➤ Chignecto

➤ York

➤ Fortune

➤ Kingston

➤ Brookfield

CR derived from *B. rapa* subsp. *rapifera* or European rutabaga

(*Shattuck and Proudfoot 1990*)

# 1<sup>st</sup> and 2<sup>nd</sup> Canadian CR cultivars



- ✓ L343PC
- ✓ L234PC
- ✓ L350PC
- ✓ LR354PC
- ✓ L358HPC
- ✓ L359HPC

- ✓ L345PC
- ✓ L356PC
- ✓ L245 HPC
- ✓ L135C
- ✓ L241C
- ✓ L255PC



- ✓ 6217TF
- ✓ CS3100TF
- ✓ CS2000



- ✓ SY4105
- ✓ SY4187

## PIONEER/CORTEVA



- ✓ 45H29
- ✓ P501L
- ✓ P505MSL
- ✓ 45CS40
- ✓ 45CM39
- ✓ P516L
- ✓ B3017N
- ✓ B3014
- ✓ B3010M
- ✓ B3016
- ✓ B3012



- ✓ PV 781TCM
- ✓ PV 661 LCM
- ✓ PV 881 OCM
- ✓ PV 780 TC
- ✓ PV 681 LC



- ✓ PV 9558
- ✓ VR 9562
- ✓ PV 580
- ✓ PV 581
- ✓ PV 585



- ✓ DK400TL
- ✓ DKTF98CR
- ✓ DKTF22CRSC
- ✓ 74-54
- ✓ 75-42



- ✓ V12-3
- ✓ V14-1
- ✓ V24-1
- ✓ V25-3T
- ✓ V25-5T



- ✓ CS4000 LL
- ✓ CS3100 TT
- ✓ CS2800 CL
- ✓ CS2600 CR-T
- ✓ CS3000 TF

## Dow AgroS

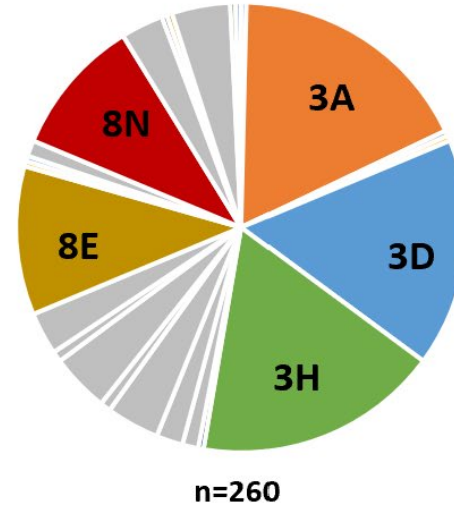


- ✓ 1020 RR
- ✓ 1024 RR
- ✓ 2020 CL

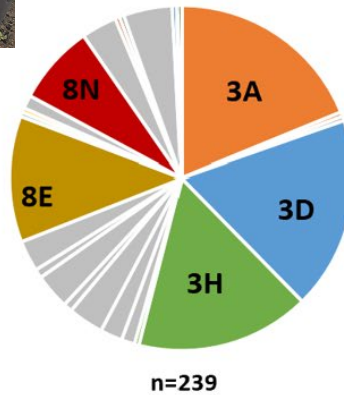
# Relative abundance of *P. Brassicae* pathotypes identified in 2019 & 2020



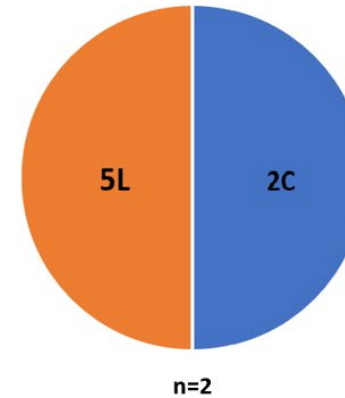
Prairies



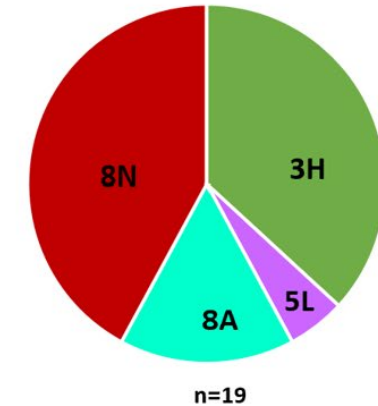
Alberta



Manitoba



Saskatchewan



# Response to clubroot resistance breakdown in canola

## Identifying and pre-breeding disease resistance

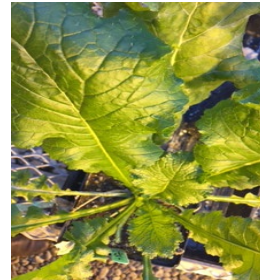
### A. Challenges

- Resistance breakdown continues to a problem
- Continued emergence of 'new' pathotypes
- Most '2nd generation' cultivars developed moderate to high clubroot severity (ID = 56%-89%)

### B. Benefits

- Finding new resistance resources to clubroot
- Mapping CR genes
- CR gene rotation by producers

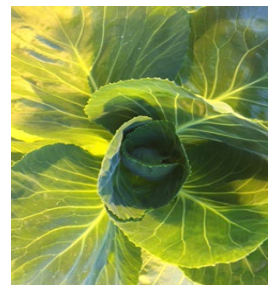
### C. Worldwide collection of 1200 Brassica germplasm



*Brassica rapa*



*Brassica nigra*



*Brassica oleracea*



*Brassica juncea*



*Brassica napus*



*Brassica carinata*

### D. Screening germplasm accessions for resistance to clubroot and other canola diseases



Susceptible



Resistant

### E. Pre-breeding to introgress resistant genes into spring canola



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# Brassica germplasm screened

- *Brassica rapa* (AA) = 178
- *Brassica nigra* (BB) = 123
- *Brassica oleracea* (CC) = 205
- *Brassica juncea* (AABB) = 232
- *Brassica napus* (AACCC) = 205
- *Brassica carinata* (BBCC) = 142

1085

# *P. brassicae* SSI & field isolates

- *'Old' (Pre-2009) SSI*
  - ✓ Pathotype 2F, 3H, 5I, 6M and 8N

5 Single spore isolates (SSI)

- *2012-2013 Disease Survey*
  - ✓ 5X (L-G1, L-G2 and LG3)
  - ✓ 5L (D-G3)

- *2013-2014 Disease Survey*
  - ✓ 3A, 3H, 2B, 3D and 5I
  - ✓ 5G(1), 8E, 5G(2) and 5C

- *2014-2015 Disease Survey*
  - ✓ 8J
  - ✓ 5K

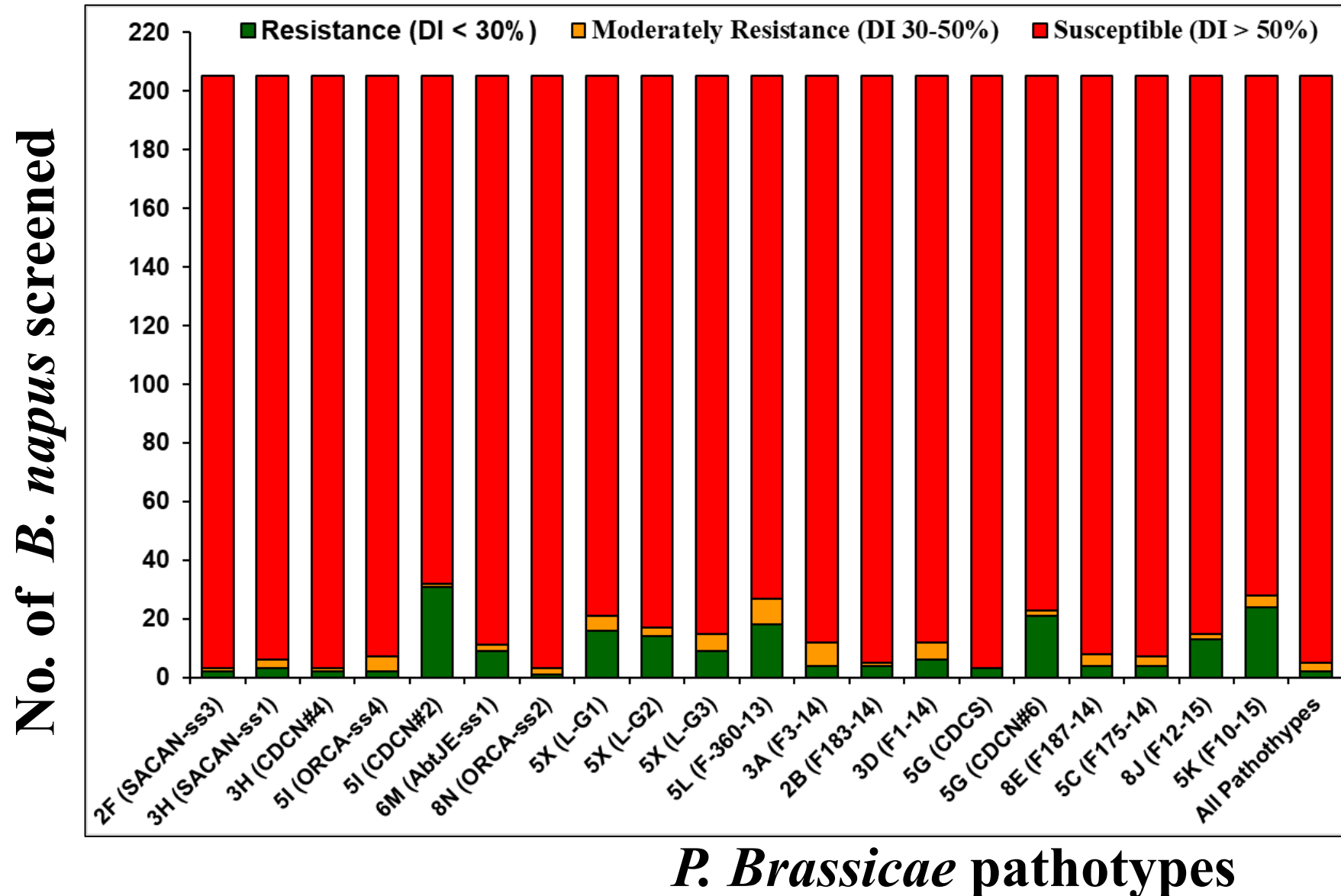
- *2015-2016 Disease Survey*
  - ✓ 3O
  - ✓ 8P

17 Field isolates



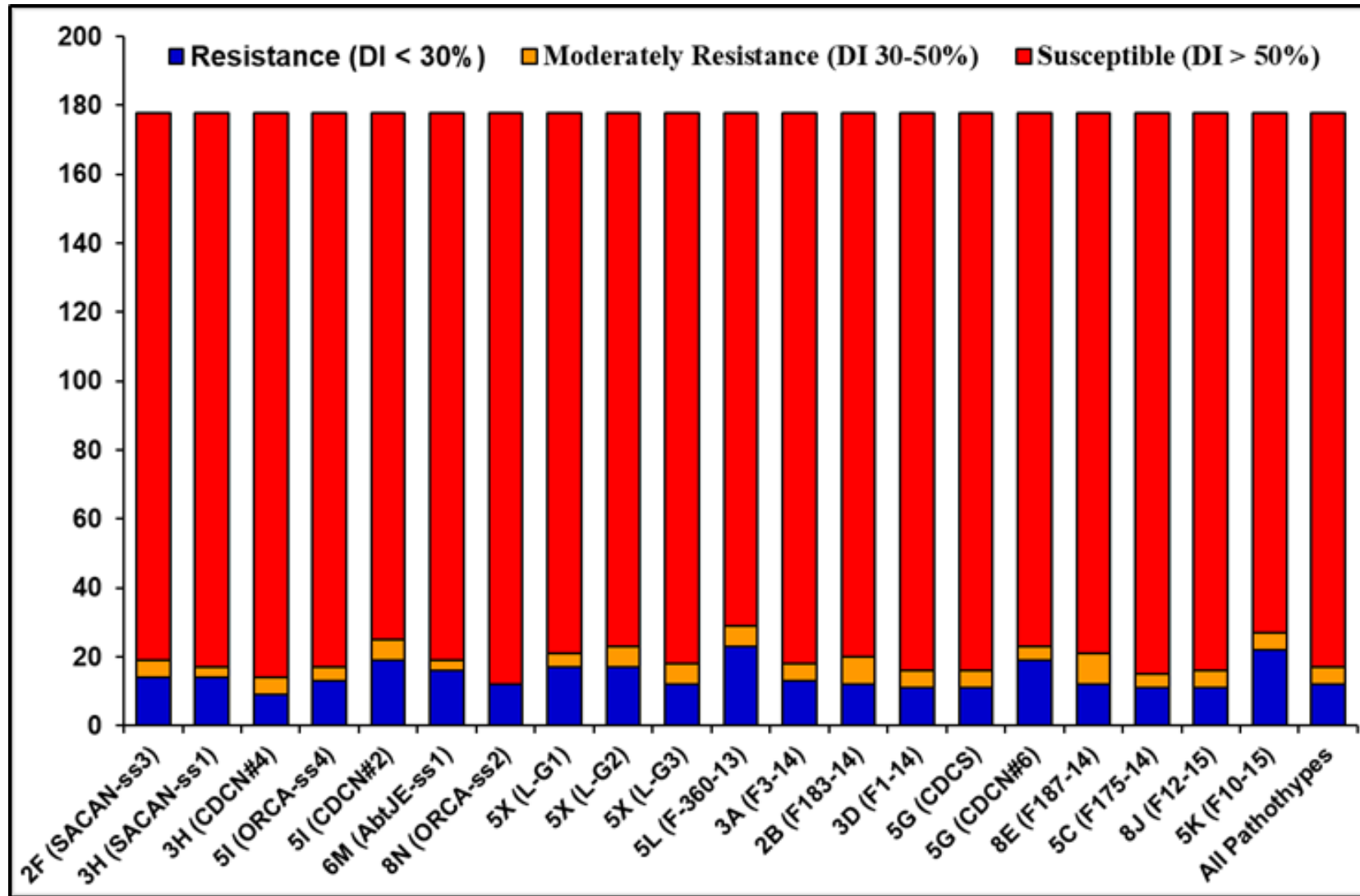
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# Frequency distribution of 205 *B. napus* accessions to 5 SSIs + 17 field isolates of *P. brassicae*



# Frequency distribution of 178 *B. rapa* accessions to 5 SSIs + 17 field isolates of *P. brassicae*

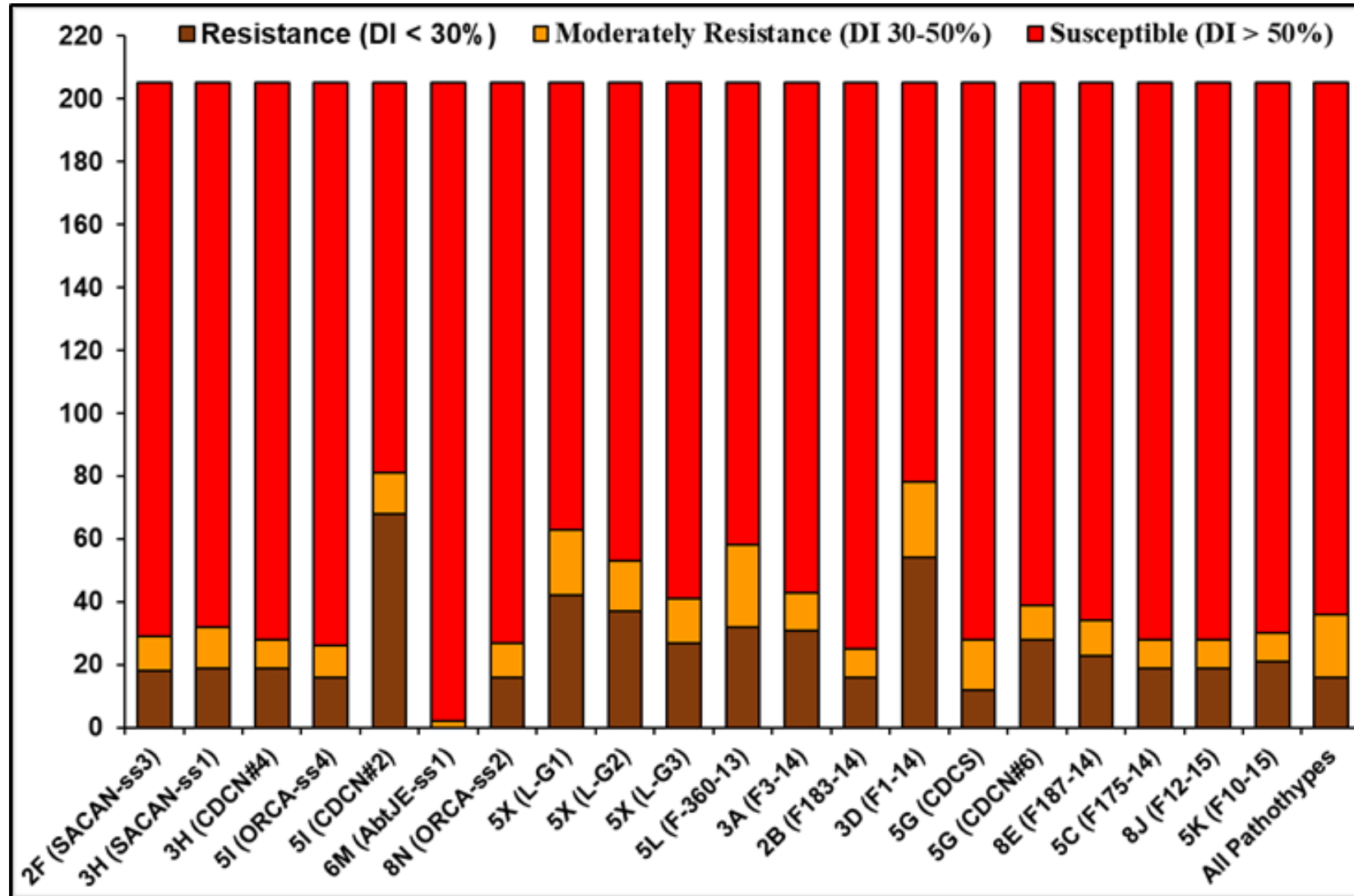
No. of *B. rapa* screened



*P. Brassicae* pathotypes

# Frequency distribution of 205 *B. oleracea* accessions to 5 SSIs + 17 field isolates of *P. brassicae*

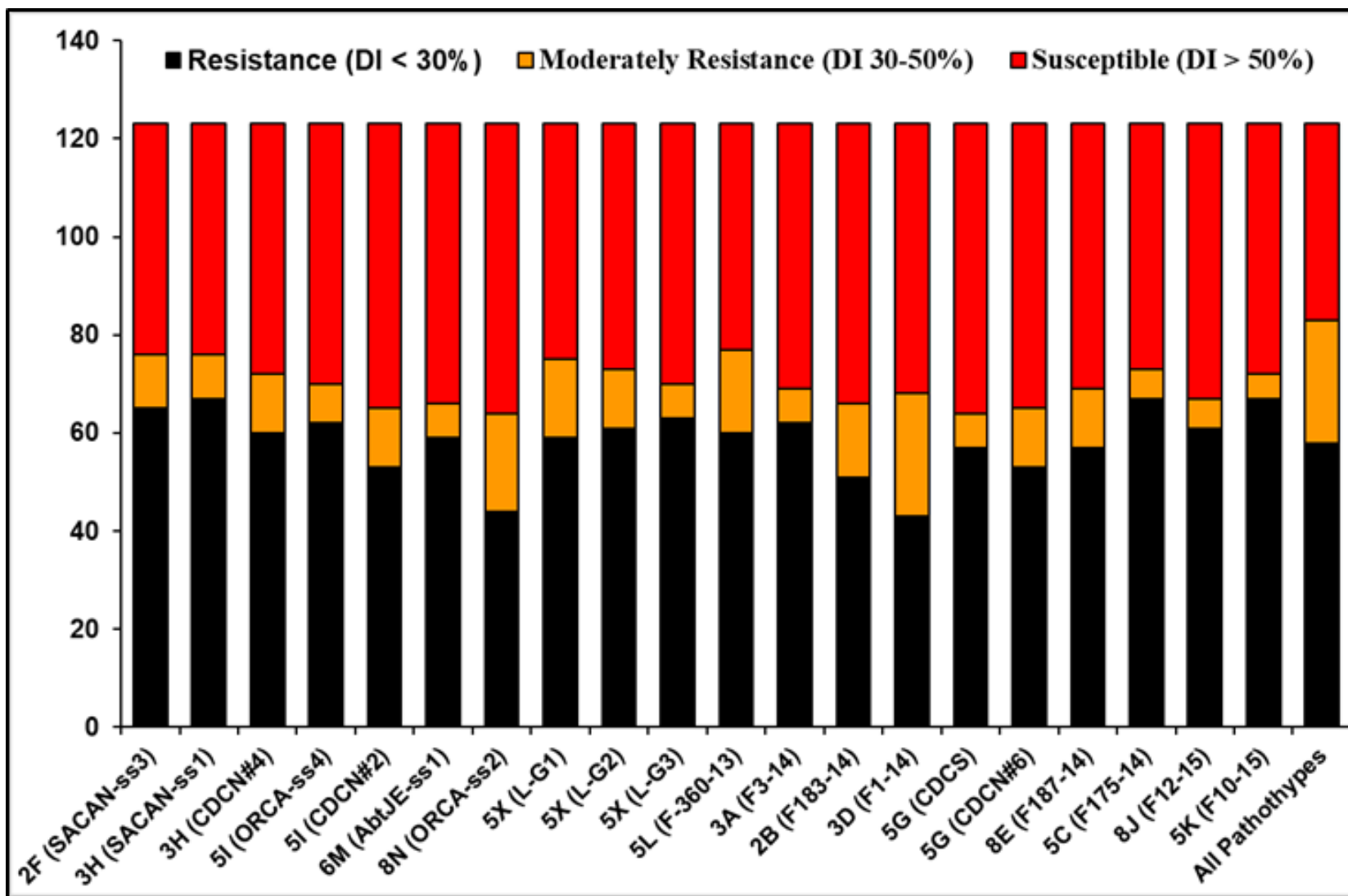
No. of *B. oleracea* screened



*P. Brassicae* pathotypes

# Frequency distribution of 123 *B. nigra* accessions to 5 SSIs + 17 field isolates of *P. brassicae*

No. of *B. nigra* screened



*P. Brassicae* pathotypes

# Summary – Clubroot resistance screening

## ■ The order of clubroot resistance based on mean ID of all pathotypes (Grand mean):

- *B. nigra* accessions - 47.2% R + 20.3% MR = 67.5%
- *B. oleracea* accessions - 7.8% R + 9.3% MR = 17.1%
- *B. rapa* accessions - 6.7% R + 2.8% MR = 9.5%
- *B. napus* accessions -1.0% R and 1.5% MR = 2.5%
- *B. carinata* - 100% S
- *B. juncea* -100% S

# Conclusions – Clubroot resistance screening

- The *B. nigra* accessions showed comparable resistance to isolates representing both the ‘old’ and ‘new’ *P. brassicae* pathotypes
- The *B. napus*, *B. rapa* and *B. oleracea* accessions were more R and MR to the ‘new’ *P. brassicae* pathotypes compared to the ‘old’ pathotypes
- The number of accessions identified for CR breeding
  - ✓ Qualitative resistance (R) = 30
  - ✓ Quantitative resistance (MR) = 34

# Acknowledgement



Agriculture  
and Forestry



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**COLLABORATION: April 1, 2021-March 30, 2026**

**BASF partners with University of Alberta's Faculty of Agricultural, Life and Environmental Sciences on \$1.25M research project to tackle clubroot resistance in canola**



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# Acknowledgement



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**RESEARCH PROJECT: April 1, 2023-March 30, 2028**

**CLUBROOT RESISTANT GENE FUNCTION  
BASED ON WHOLE GENOME SEQUENCES,  
GENOME EDITING AND RESISTANCE  
PHENOTYPES**



**\$833,000**



**\$208,334**



**\$208,334**

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