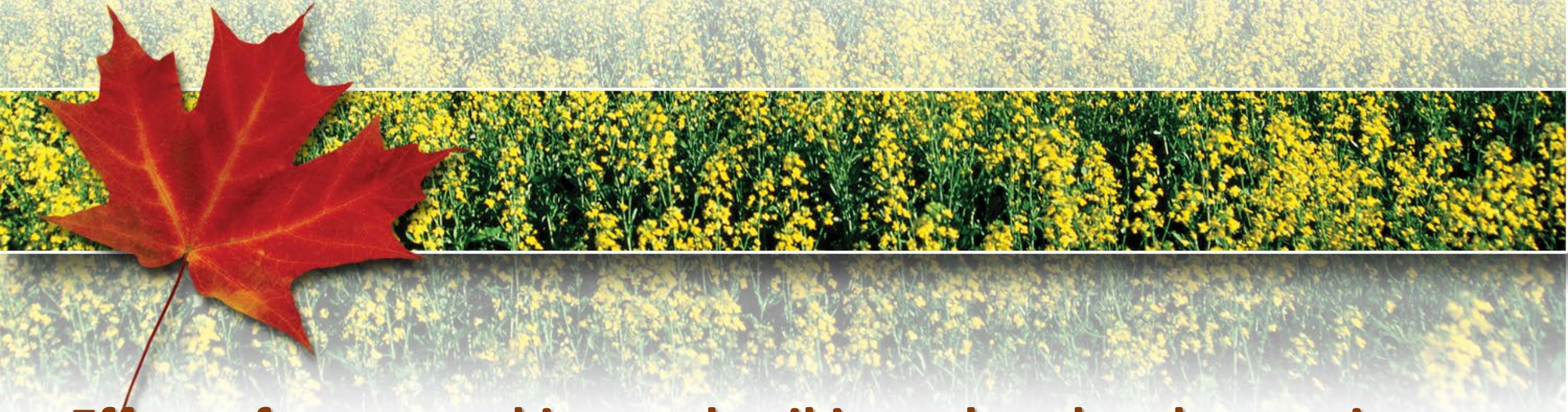




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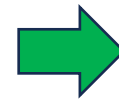
Canada



Effect of gene stacking and soil inoculum level on resistance resilience of canola against clubroot caused by pathotype **3H**

Wen R, Song T, Peng G –AAFC Saskatoon Research Center
Franke C. – Nutrien Ag. Solutions, Saskatoon

Durability of resistance –a challenge



A 'Mendel' type of CR gene (**A03**) introduced in 2009 was highly effective against clubroot caused by pathotype **3H**, the predominant type in western Canada

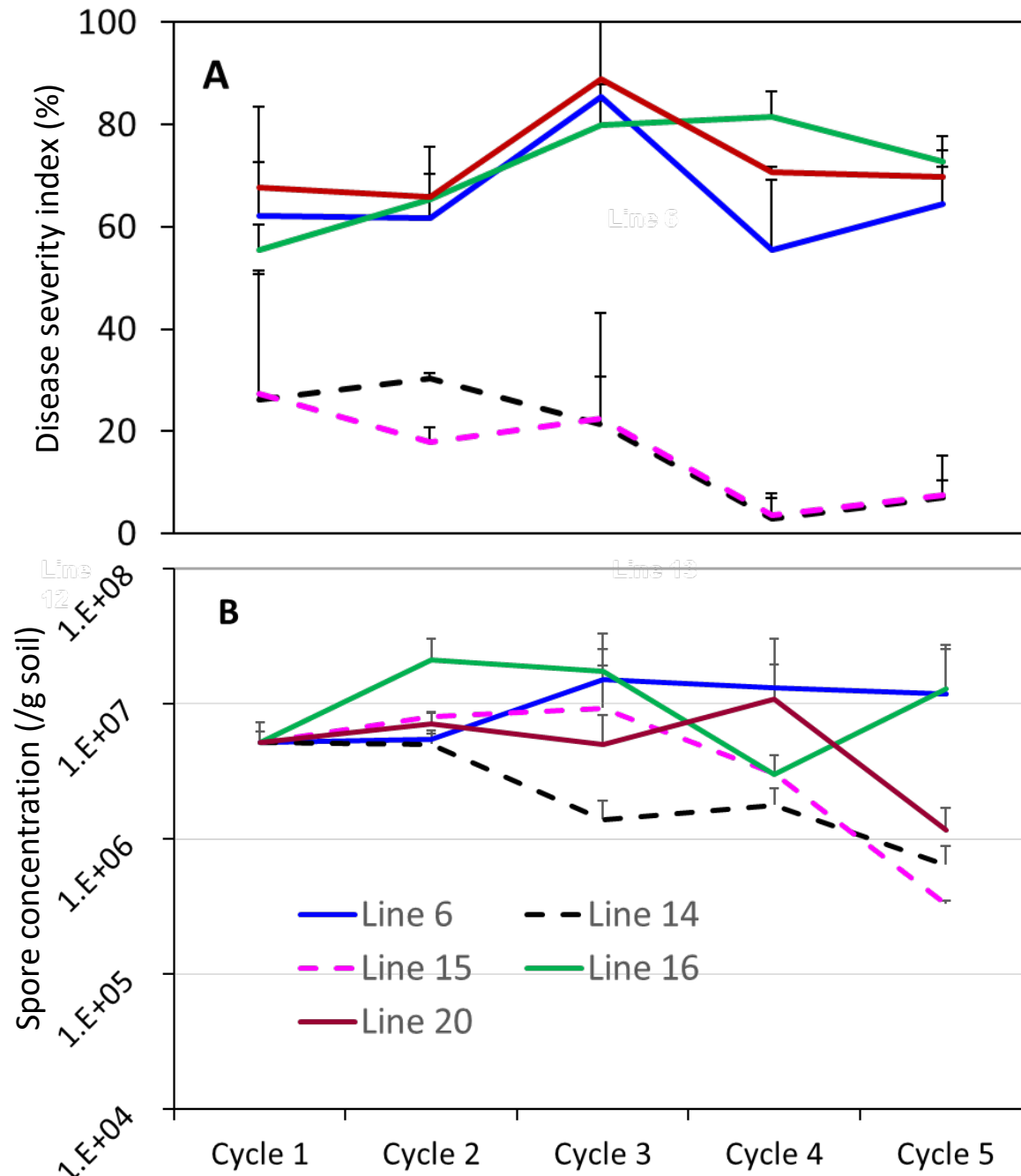


By 2013, the resistance was overcome in a field by a novel variant pathotype **X**

>30 pathotypes have been identified....

Inbred/hybrid canola lines carrying single/double CR genes

Lines	CR genes	CR-gene location	Reaction to pathotype 3H	Reaction to pathotype X
Westar	<i>None</i>	N/A	Susceptible (S)	S
Line 13	<i>Rcr1/Rcr1</i>	A03/A03	Resistant	S
Line 14	<i>Crr1^{rutb}/Rcr1</i>	A08/A03	Resistant	Moderately R (MR)
Line 20	<i>Crr1^{rutb}</i>	A08	Resistant	R – MR – S



Stacking CR genes against pathotype X



Article

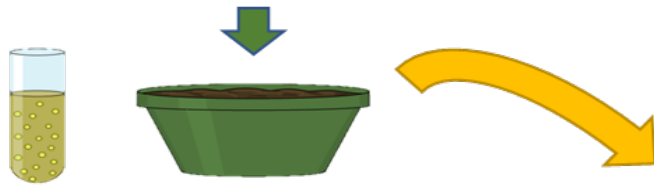
Canola with Stacked Genes Shows Moderate Resistance and Resilience against a Field Population of *Plasmodiophora brassicae* (Clubroot) Pathotype X

Nazmoon Naher Tonu^{1,†}, Rui Wen¹, Tao Song^{1,‡}, Xiaowei Guo², Lee Anne Murphy², Bruce Dean Gossen¹, Fengqun Yu¹ and Gary Peng^{1,*}

- ❖ Canola stacked with CR genes **Rcr1 (A03)** and **Crr1^{rutb} (A08)** exhibited moderate resistance to pathotype X
- ❖ Any of the single genes alone was ineffective or with variable efficacy
- ❖ Stacked CR genes, despite MR, improved the resistance resilience and hindered pathogen inoculum buildup in soil.

CR durability (5 planting cycles) against pathotype 3H

Mixing resting-spore suspensions into soil (1st cycle only) for low ($10^4/g$) and high ($10^7/g$) initial inoculum levels



Mixing decomposed galls into soil, quantify resting spores with ddPCR

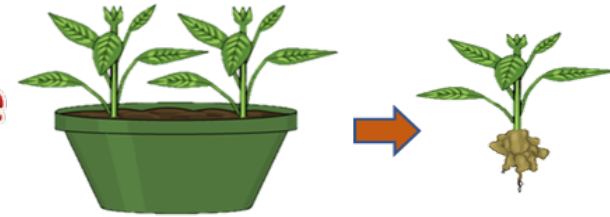


Burying galls in damp soil for 3 wks to allow galls to decompose and resting spores to mature

Planting



Disease assessment
(6 weeks after seeding)



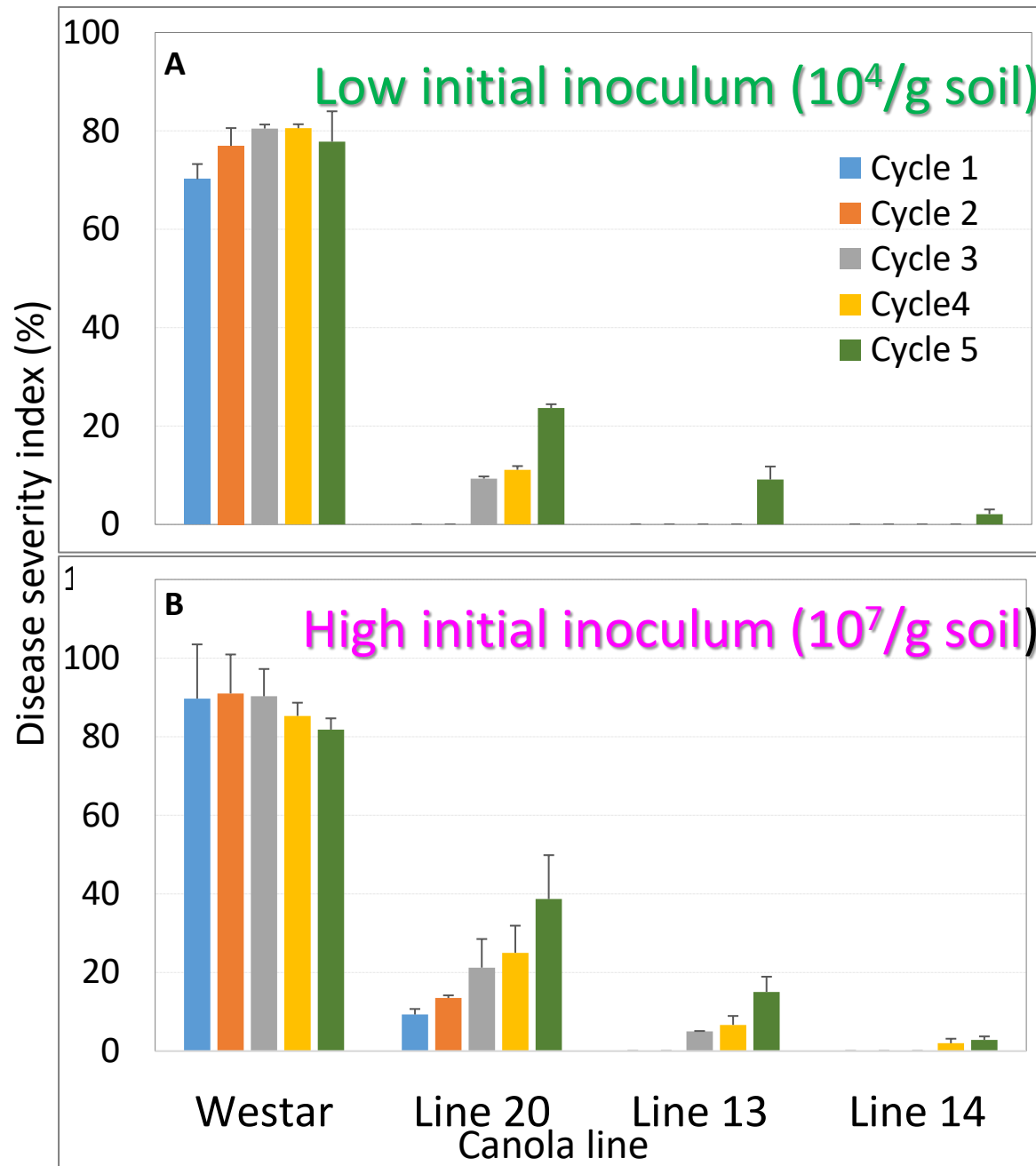
A single planting cycle



Keeping roots & galls



Two repetitions –each repeat took 13 months to complete



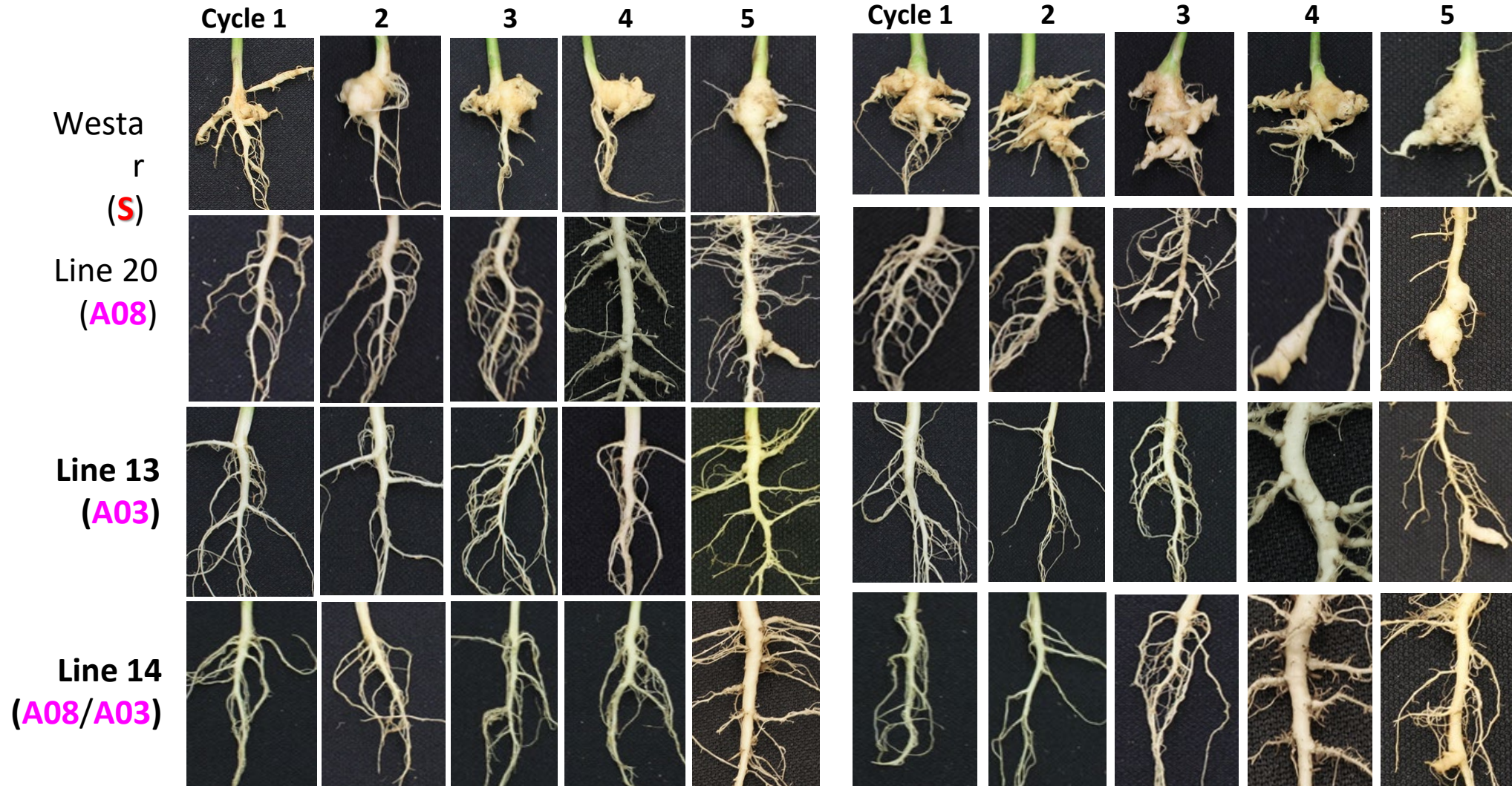
Resistance efficacy of canola lines carrying single vs. stacked CR genes over 5 cycles of exposure to a field population of pathotype 3H under low (10^4 /g) and high (10^7 /g) initial soil inoculum conditions

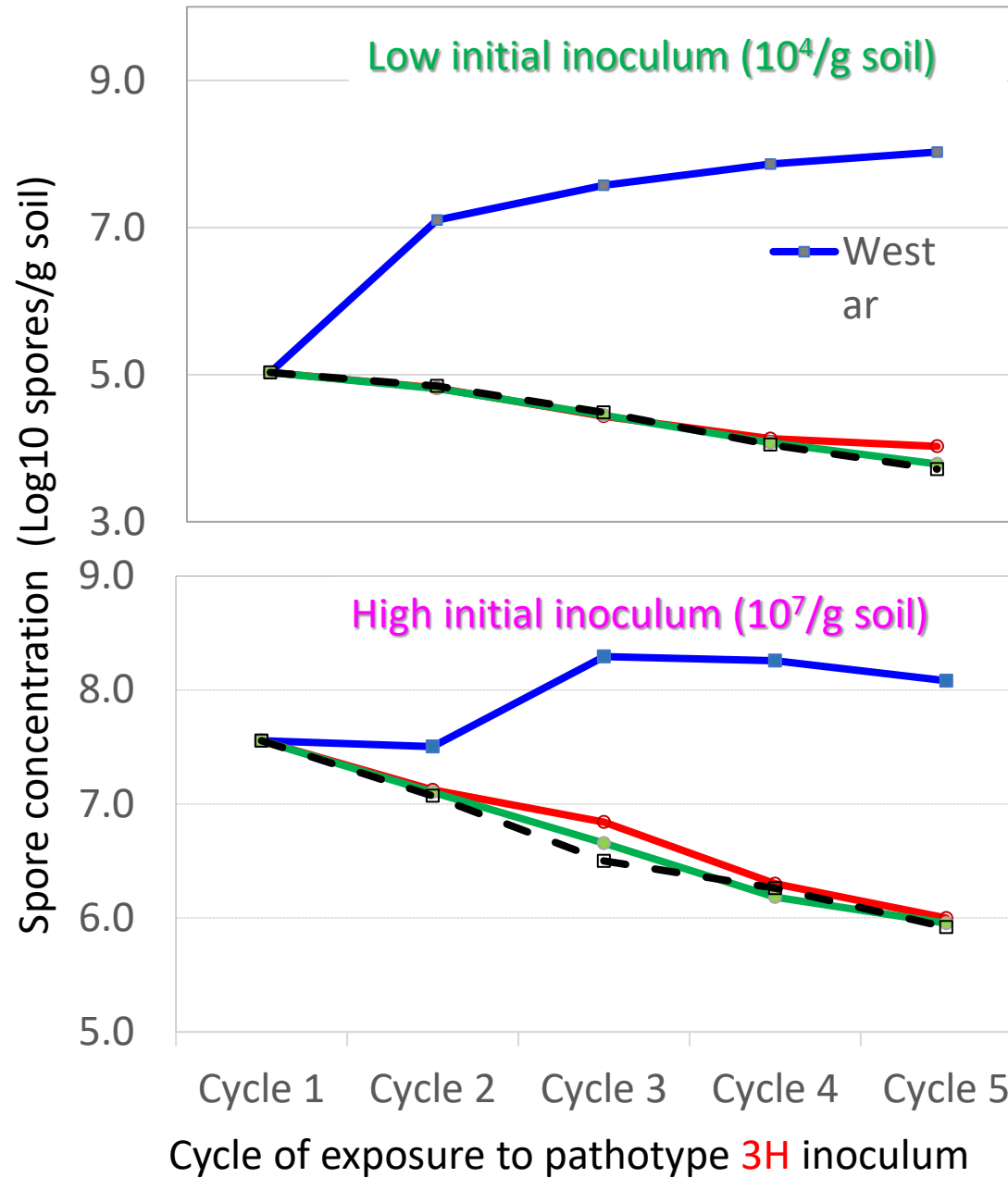
- ❖ Lines carrying single CR gene *Rcr1* or *Crr1^{rutb}* showed resistance to pathotype 3H initially
- ❖ Resistance of single CR gene showed decline over time, especially for the Line 20 (A08) at the high initial inoculum
- ❖ Stacked CR genes (Line 14) showed greater resistance resilience over time.

Disease severity over 5 cycles of exposure to a field population of pathotype 3H

Low initial inoculum (1×10^4 /g soil)

High initial inoculum (1×10^7 /g soil)





Changes in resting spore concentration in soil over time

- ❖ The soil inoculum level increased over time when the susceptible Westar was grown continuously
- ❖ Canola lines carrying single or stacked CR genes reduced soil inoculum steadily
- ❖ Canola with stacked CR genes may reduce virulent inoculum more effectively.

Reducing soil inoculum helps CR resilience



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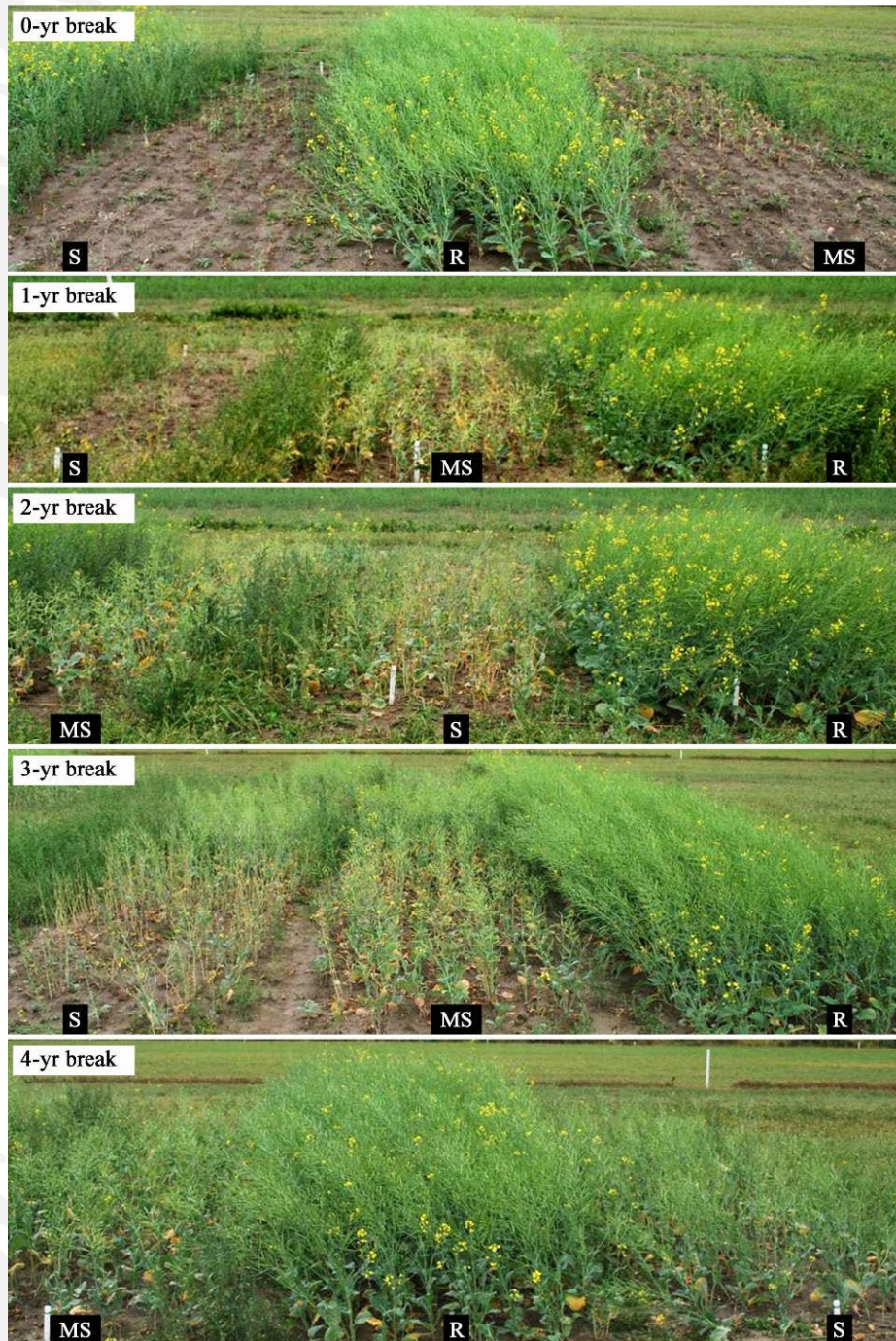
European Journal of Agronomy

journal homepage: www.elsevier.com/locate/eja



A >2-year crop rotation reduces resting spores of *Plasmodiophora brassicae* in soil and the impact of clubroot on canola

Gary Peng^{d,*}, Denis Pageau^a, Stephen E. Strelkov^b, Bruce D. Gossen^d, Sheau-Fang Hwang^c, Rachid Lahlali^d



A break from previous susceptible canola

Conclusions:

- ❖ The canola line with stacked ***Rcr1*** (A03) and ***Crr1^{rutb}*** (A08) genes exhibited greater resistance resilience to a field population of *P. brassicae* pathotype **3H** than those carrying either of the single genes
- ❖ Growing resistant canola cultivars, with either a single or multiple CR genes, reduce *P. brassicae* inoculum buildup in soil over time
- ❖ Erosion of single-gene resistance appears more rapid under high soil inoculum, so any practice reducing *P. brassicae* resting-spore buildup in soil, such as a >2-year break between canola, will likely enhance the resistance resilience

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Acknowledgement

- ❖ Technical assistance: Jillian Lee and Kylie Hornaday (Co-op Students)
- ❖ Funding support: Canadian Agricultural Partnership program supported by AAFC and canola growers.

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