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Managing blackleg of canola – potential new tools

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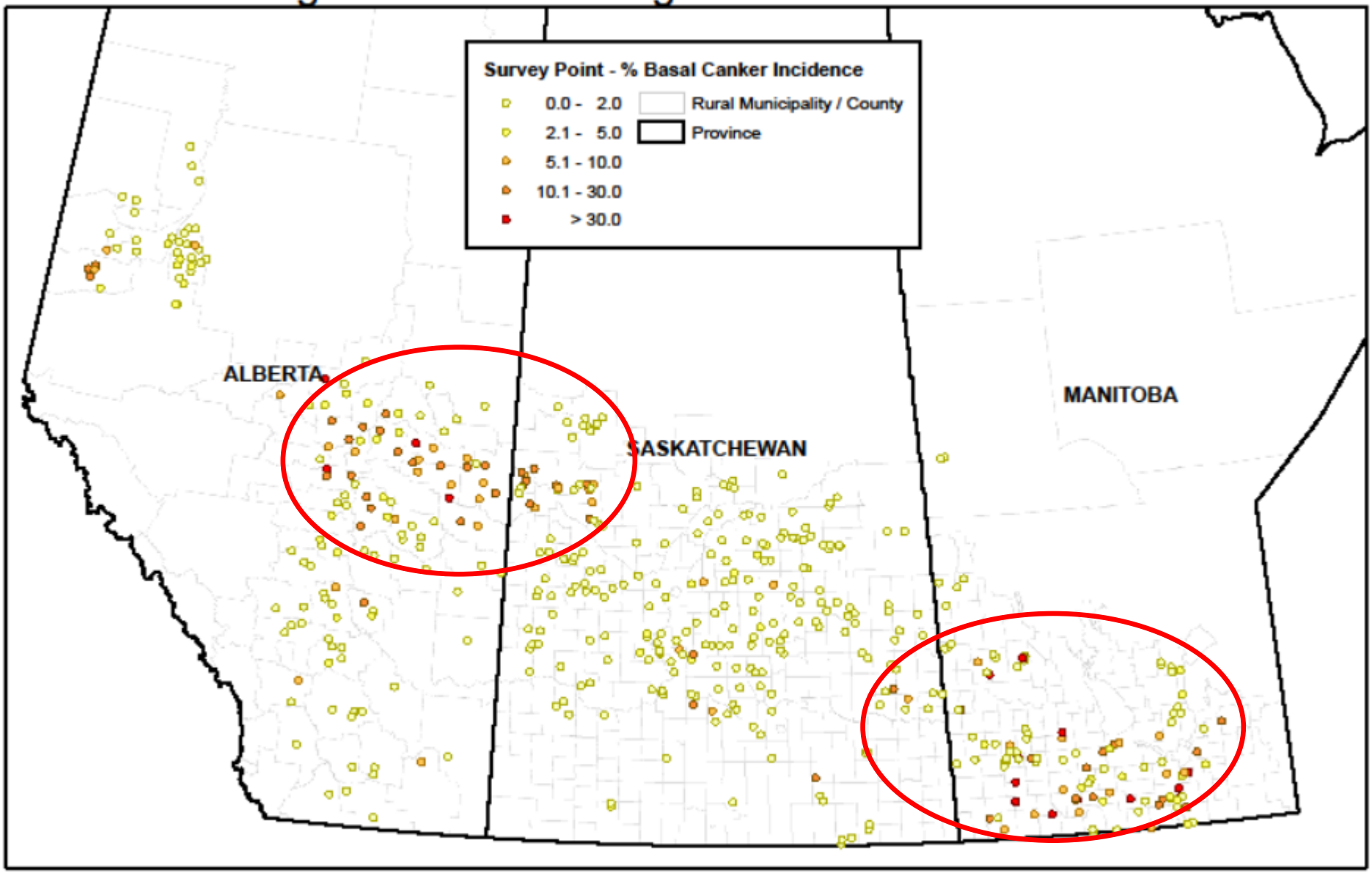
Canada

Background

- For many years, blackleg disease of canola was managed effectively with resistant cultivars in conjunction with 4-yr crop rotation
- *Leptosphaeria maculans* race structure has been changing, influenced by *R* genes used in canola cultivars and environmental conditions
- Crop rotation has been tightened in recent years in favor of canola production
- Blackleg disease is on the rise, more noticeable in some regions than others on the prairies

Average Percent Blackleg Incidence in Canola - 2011



Saskatchewan Ministry of Agriculture

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0 50 100 200 300 400 500

Kilometers

Projection: UTM Zone 13 Datum: NAD83

N W E S

Data Source:
Canola Survey Data - Crops Branch
Collaboration with: Agriculture and Agri-Food Canada, Manitoba, Government of Alberta, canola council

Prepared by: Geomatics Services Date: April 2, 2012

Blackleg survey in Saskatchewan - 2012

Region	No. fields surveyed	% Fields with Blackleg	Avg. disease incidence (%)
NW	54	**48**	**16.6**
NE	45	27	8.1
WC	36	14	3.0
EC	61	34	5.0
SW	14	36	6.6
SE	43	**30**	**20.2**
Province	253	32	11.2

Data compiled by SK Ministry of Agriculture

What factors can influence the increase of blackleg disease?

- Pathogen population: –race structure. The type & frequency of Avirulent (*Av*)/avirulent (*av*) alleles
- Resistance genes in canola cultivars (specific & quantitative resistance genes)
- Occurrence and reproduction of new pathogen races that are able to overcome *R* genes – The rate of reproduction would be higher under short crop rotations

Fungicides and their timing when "resistance breaks down (worst case scenario)

I. LM race structure and dynamics

Pathogen-host interaction (seedling stage)

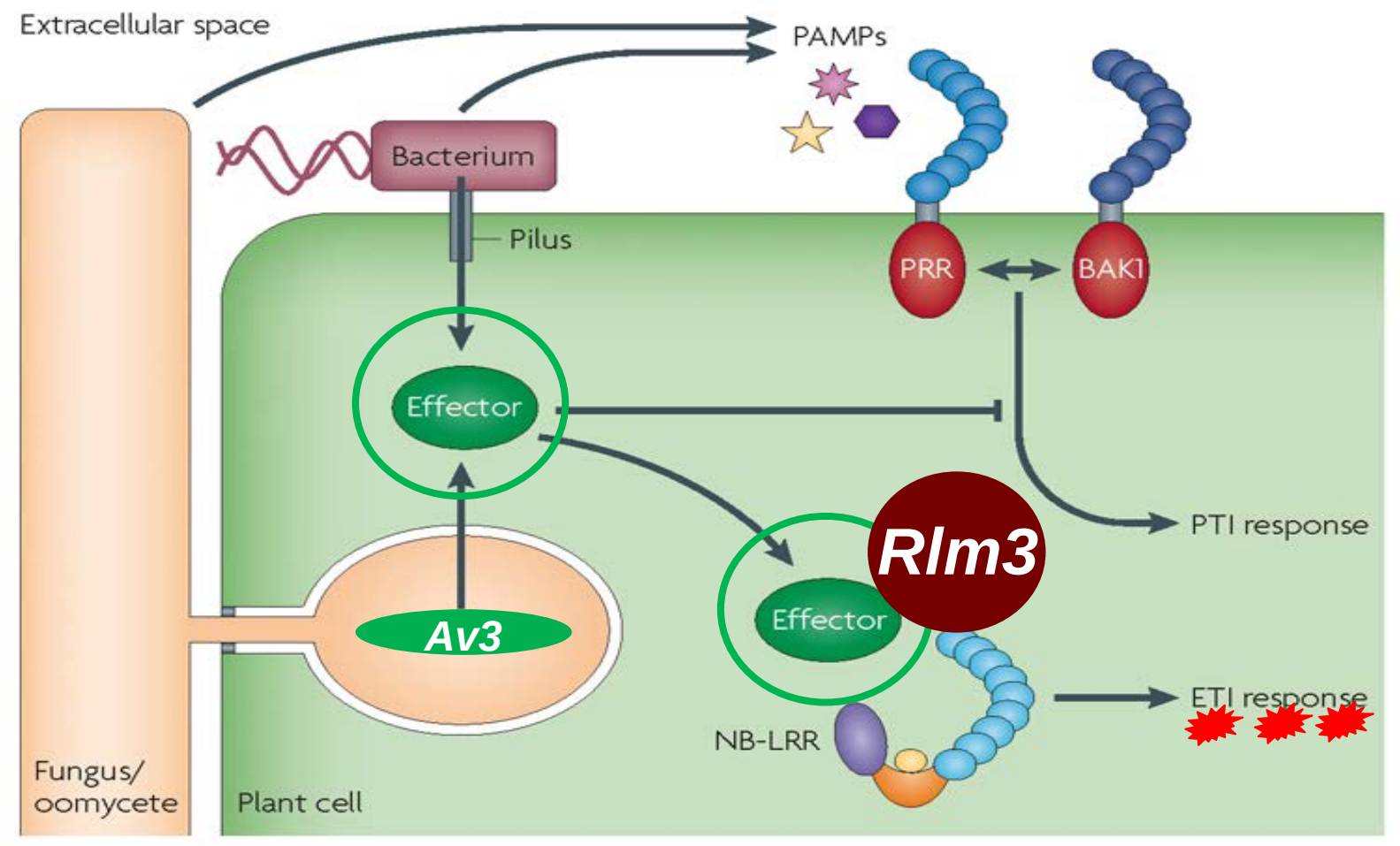
Specific *R* gene	*L. maculans Av* gene
Rlm1	*Av1*
Rlm2	*Av2*
Rlm3	*Av3*
Rlm4	*Av4*
Rlm5,6	*Av5,6*
Rlm7	*Av4*
Rlm8	*Av8*
Rlm9	*Av9*
Rlm10	*Av10*
LepR1	*AvLep1*
LepR2	*AvLep2*
LepR3	*AvLep3*
LepR4	*AvLep4*

LM-canola interaction

Rlm3 *AvLm3*

Rlm3 *avLm3*

Perception of pathogens by plants -effectors



PAMPs: Pathogen-associated molecular patterns (extracellular)
PTI: PAMP-triggered immunity
Effector: Pathogen proteins in the host cytoplasm
ETI: Effector-triggered immunity (intra-cellar)

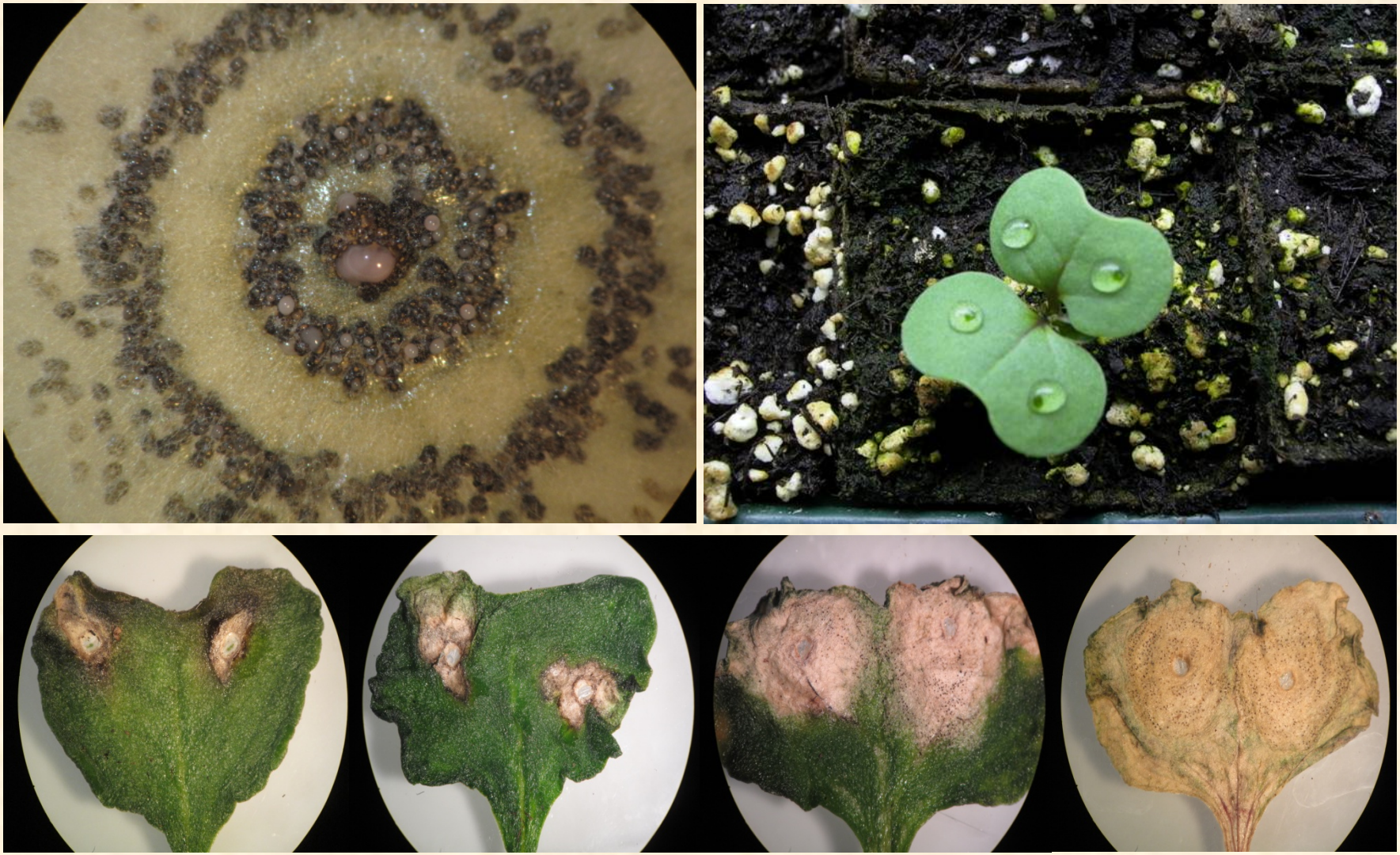
Dodds & Rathjen (2010) Nature Rev. Gen., 11:539-548

A set of *Brassica* lines for differentiating *Av* genes in *L. maculans*

Canola lines	R-genes	Canola lines	R-genes
MT29	*Rlm1,9*	Falcon MX	*Rlm4,6*
Grizzly	*Rlm1,3*	Darmor MX	*Rlm6,9*
Cooper	*Rlm1,4*	Cutlass	*Rlm*5,6?
Samouraï	*Rlm2,9*	23-2-1	*Rlm7*
Glacier	*Rlm2,3*	Darmor	*Rlm9*
Verona	*Rlm2,4*	Line 1065	*LepR1*
22-1-1	*Rlm3*	Line 1135	*LepR2*
Falcon	*Rlm4*	Surpass400	*Rlm1,LepR3*

Replacing the earlier PG system

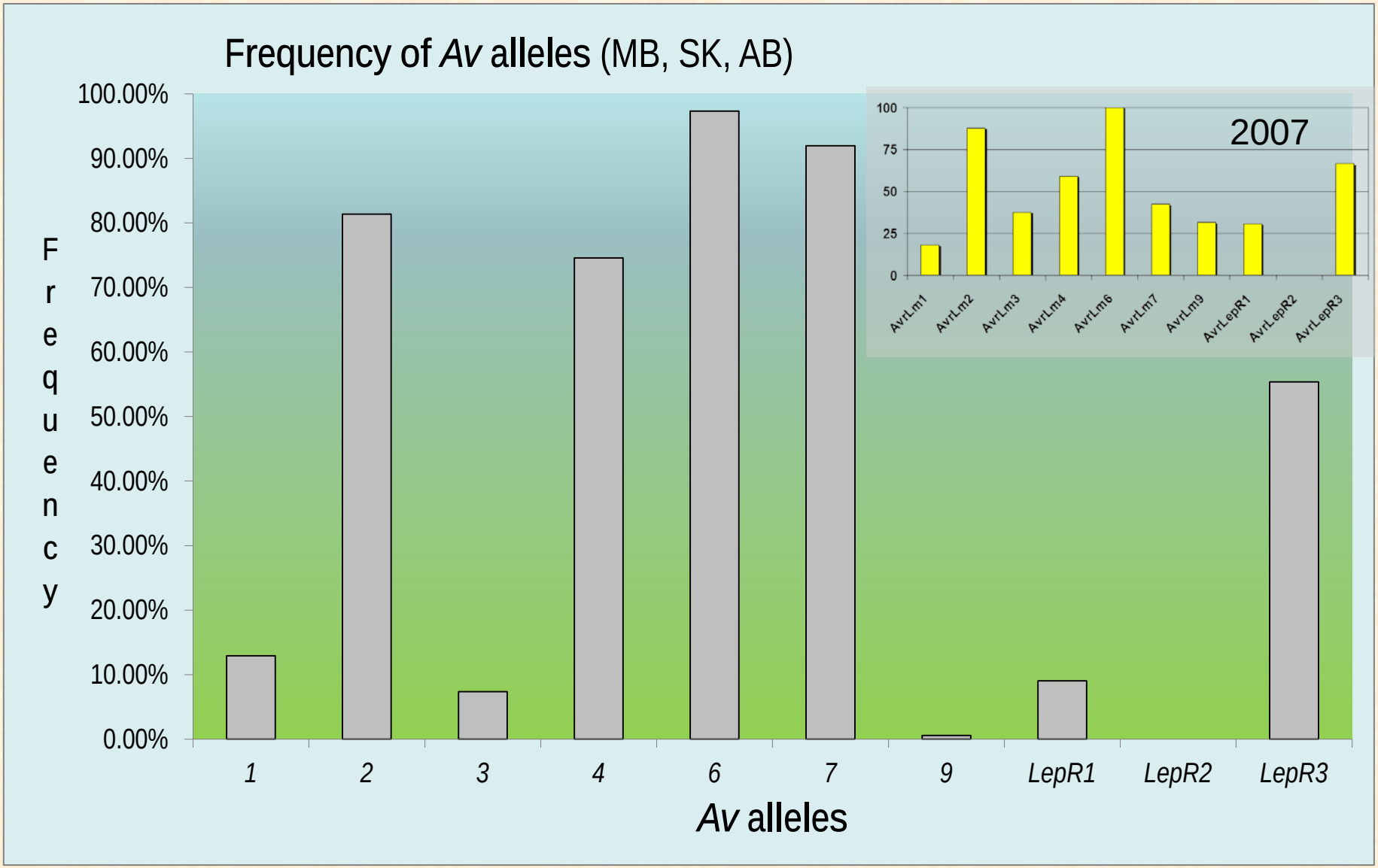
Assessment of *L. maculans* isolate with host differentials



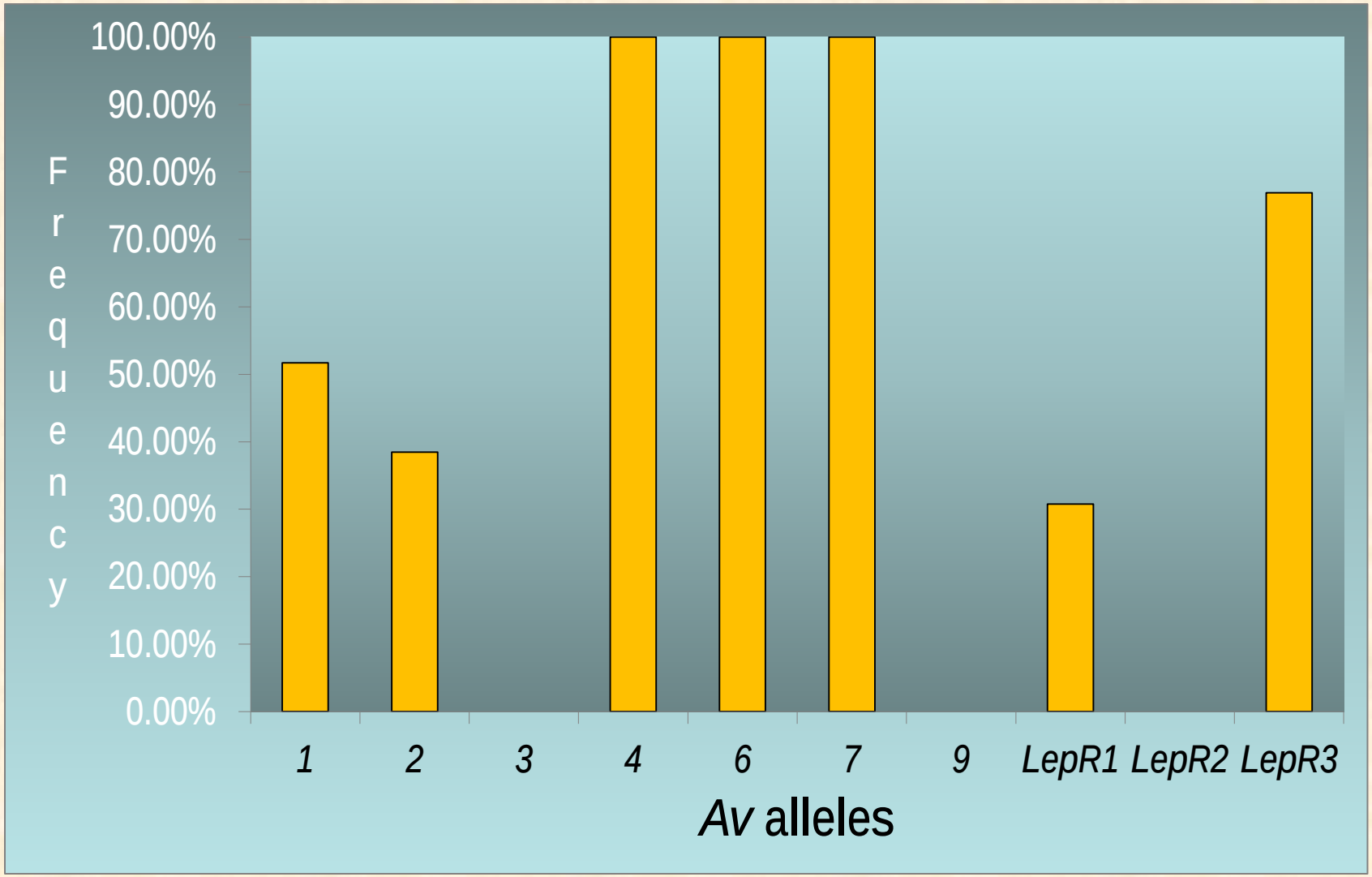
3 5 7 9

0-9 rating scale

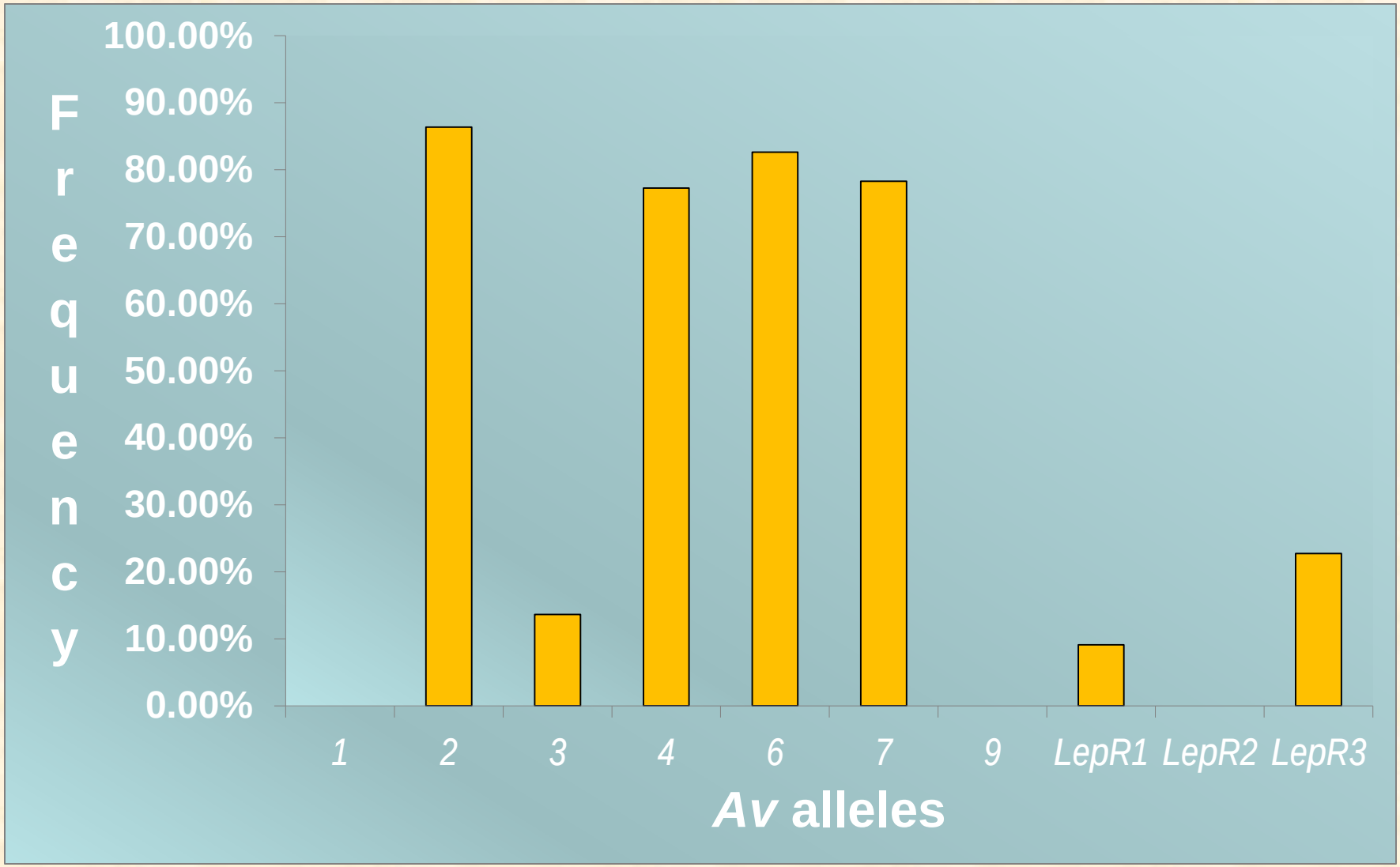
L. maculans race profile -2010



Regional variation –southern MB 2010



Regional variation –Vegreville, AB 2010



II. *R* genes in canola cultivars/lines

❖ A differential set of *L. maculans* isolates

- A total of 19 *L. maculans* isolates with defined *Av* genes were employed to determine *R* genes present in canola at Dr. Fernando's lab at U of M

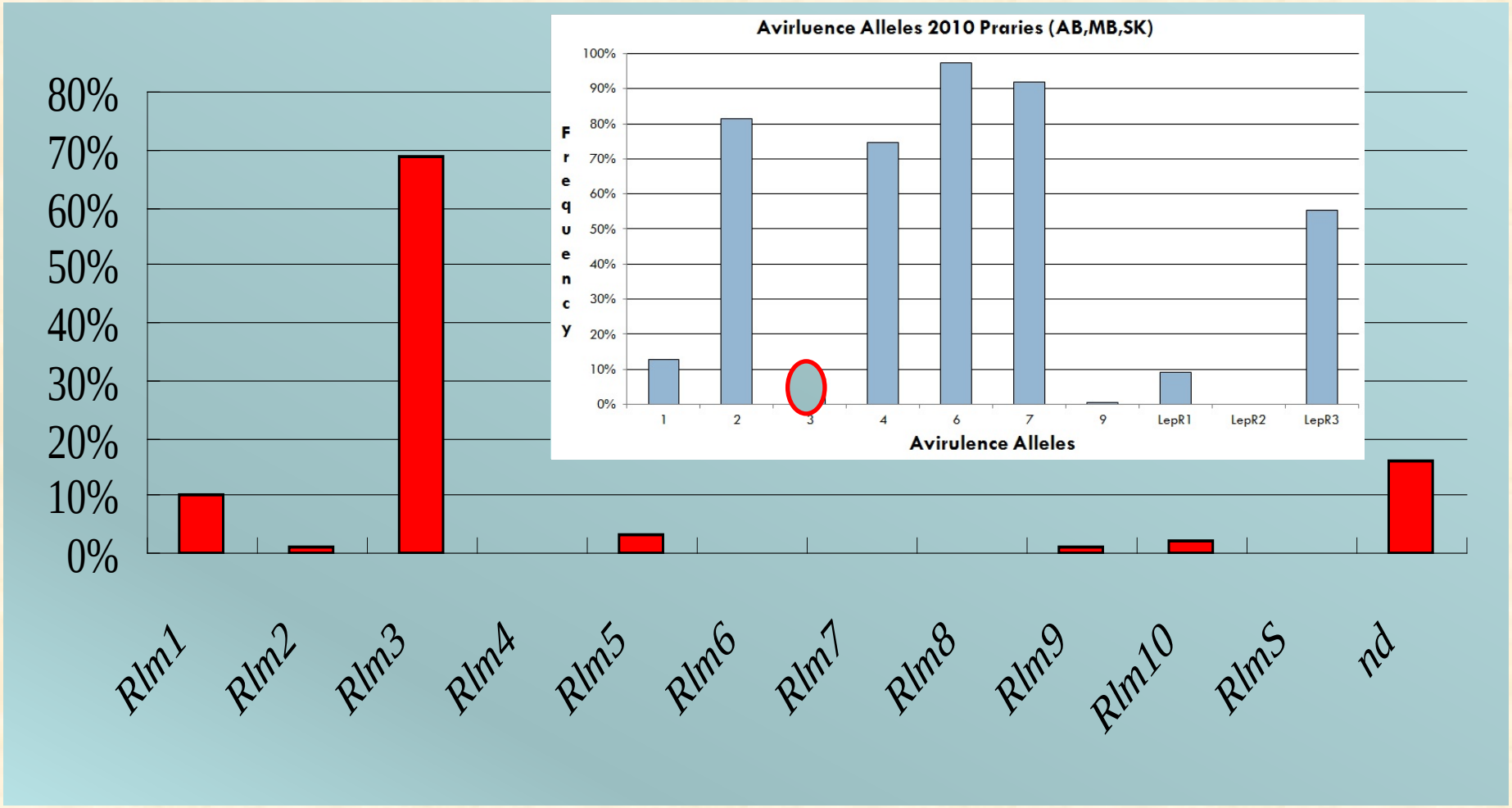
❖ Canola cultivars/lines

- A collection of 87 canola cultivars/lines obtained from several seed companies, government labs and other research institutions were characterized based on seedling inoculation using the differential set of *L. maculans* isolates.

Av genotypes of *L. maculans* isolates

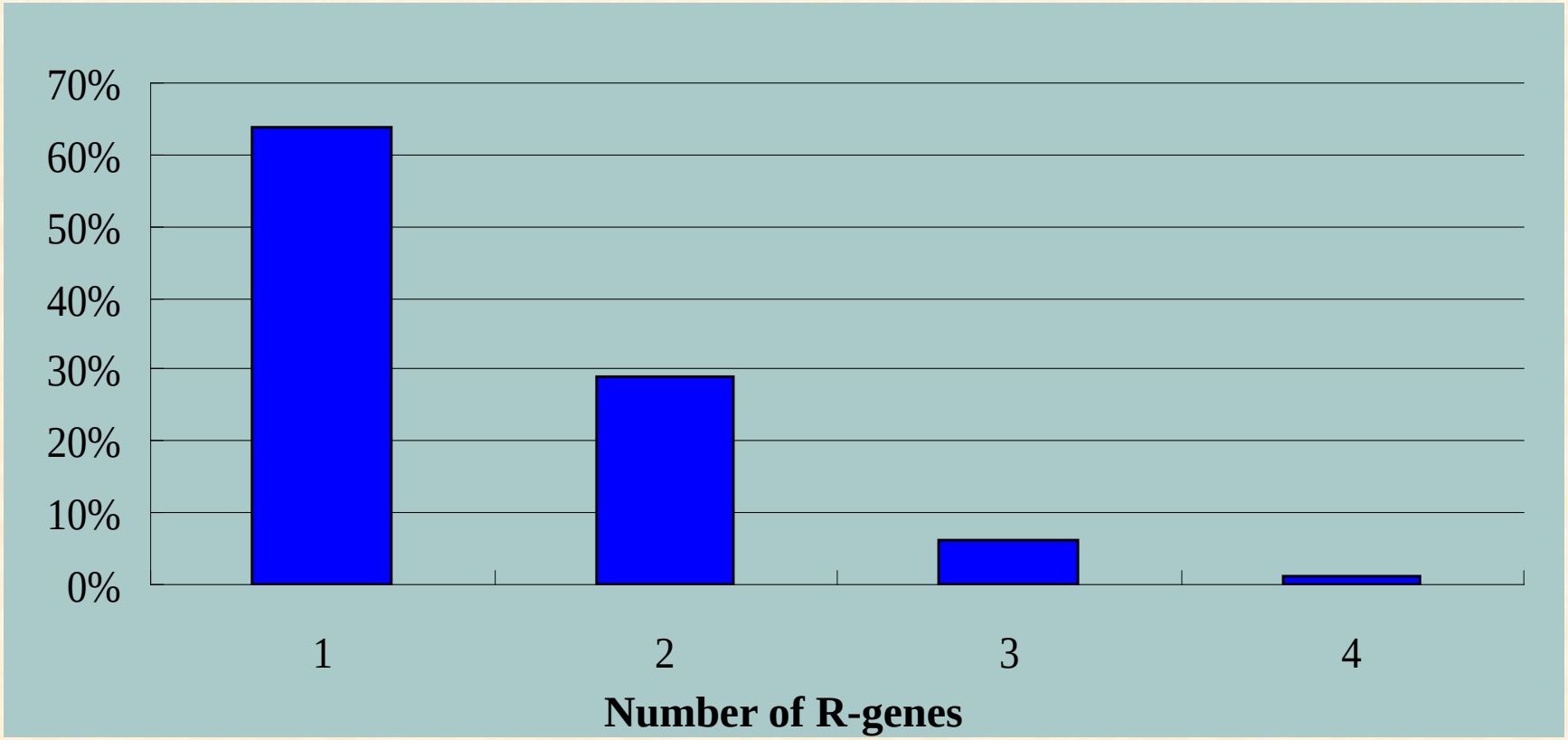
Isolates	*AvrLm1*	*AvrLm2*	*AvrLm3*	*AvrLm4*	*AvrLm5*	*AvrLm6*	*AvrLm7*	*AvrLm8*	*AvrLm9*	*AvrLm10*	*AvrLmS*
D1	*avr*	*Avr*	*avr*	*avr*	*Avr*	*Avr*	*avr*	*avr*	*Avr*	*nd*	*nd*
D2	*avr*	*avr*	*avr*	*avr*	*Avr*	*Avr*	*avr*	*Avr*	*avr*	*nd*	*Avr*
D3	*avr*	*avr*	*avr*	*avr*	*Avr*	*avr*	*avr*	*avr*	*avr*	*nd*	*avr*
D4	*avr*	*avr*	*avr*	*Avr*	*Avr*	*Avr*	*Avr*	*Avr*	*avr*	*nd*	*avr*
D5	*Avr*	*Avr*	*avr*	*Avr*	*avr*	*avr*	*Avr*	*avr*	*avr*	*nd*	*Avr*
D6	*Avr*	*avr*	*avr*	*avr*	*Avr*	*Avr*	*avr*	*Avr*	*avr*	*nd*	*Avr*
D7	*Avr*	*avr*	*Avr*	*avr*	*Avr*	*Avr*	*avr*	*Avr*	*avr*	*nd*	*nd*
D8	*avr*	*avr*	*avr*	*avr*	*Avr*	*avr*	*Avr*	*nd*	*avr*	*nd*	*avr*
D9	*avr*	*avr*	*avr*	*avr*	*Avr*	*Avr*	*Avr*	*nd*	*avr*	*nd*	*avr*
D10	*avr*	*avr*	*avr*	*avr*	*Avr*	*Avr*	*avr*	*Avr*	*Avr*	*nd*	*Avr*
D13	*avr*	*avr*	*avr*	*Avr*	*nd*	*Avr*	*Avr*	*nd*	*avr*	*nd*	*avr*
D14	*Avr*	*avr*	*avr*	*avr*	*nd*	*avr*	*Avr*	*nd*	*avr*	*nd*	*Avr*
S7	*Avr*	*avr*	*avr*	*avr*	*Avr*	*Avr*	*Avr*	*nd*	*avr*	*avr*	*avr*
ICBN14	*avr*	*avr*	*avr*	*avr*	*Avr*	*Avr*	*avr*	*avr*	*avr*	*Avr*	*avr*
PHW1223	*avr*	*avr*	*avr*	*avr*	*Avr*	*Avr*	*avr*	*Avr*	*Avr*	*avr*	*avr*
R2	*avr*	*avr*	*avr*	*avr*	*Avr*	*avr*	*Avr*	*nd*	*avr*	*Avr*	*avr*
AD-746	*avr*	*avr*	*Avr*	*avr*	*nd*	*Avr*	*avr*	*nd*	*avr*	*avr*	*avr*
JN2	*avr*	*avr*	*avr*	*avr*	*Avr*	*Avr*	*Avr*	*Avr*	*avr*	*avr*	*avr*
JN3	*Avr*	*avr*	*avr*	*Avr*	*Avr*	*Avr*	*Avr*	*Avr*	*avr*	*avr*	*avr*

R genes found in 87 canola cvs/lines



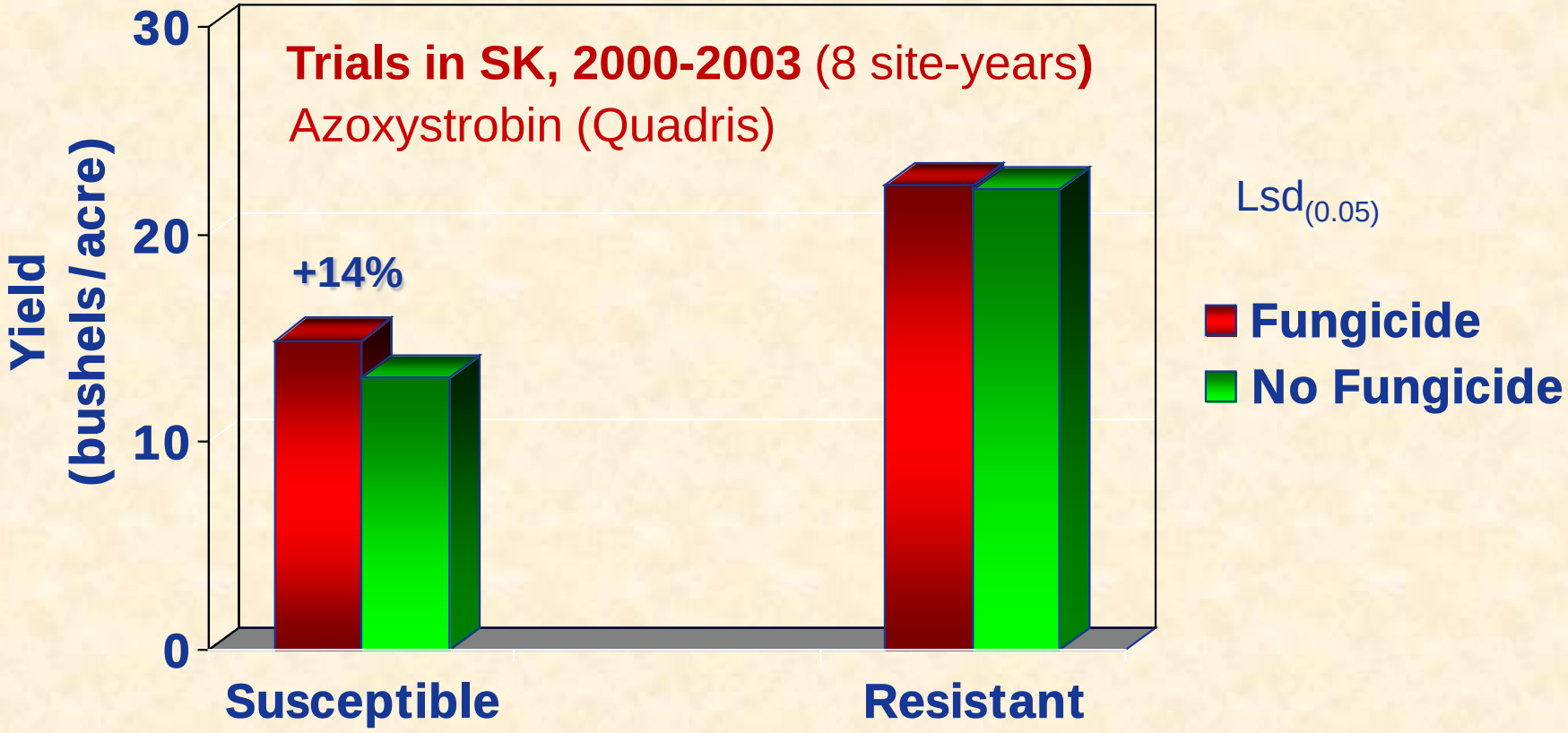
Percentage of cultivars/lines carrying each R-gene

R genes in 87 canola cultivars/lines



Percentage of cultivars/lines carrying multiple R-genes

III. Fungicides & application timing



By HR Kutcher

New fungicides and application timing

Treatments

On S cultivar (no *R*-genes)

1. Non-treated control
2. Headline @2-4 leaf stage
3. Quadris @2-4 leaf stage
4. Tilt @2-4 leaf stage
5. Quilt @2-4 leaf stage
6. Headline @just prior to bolting
7. Tilt @2-4 leaf, Headline @pre-bolting
8. Headline @2-4 leaf, Tilt @pre-bolting

On MR cultivar (43E01)

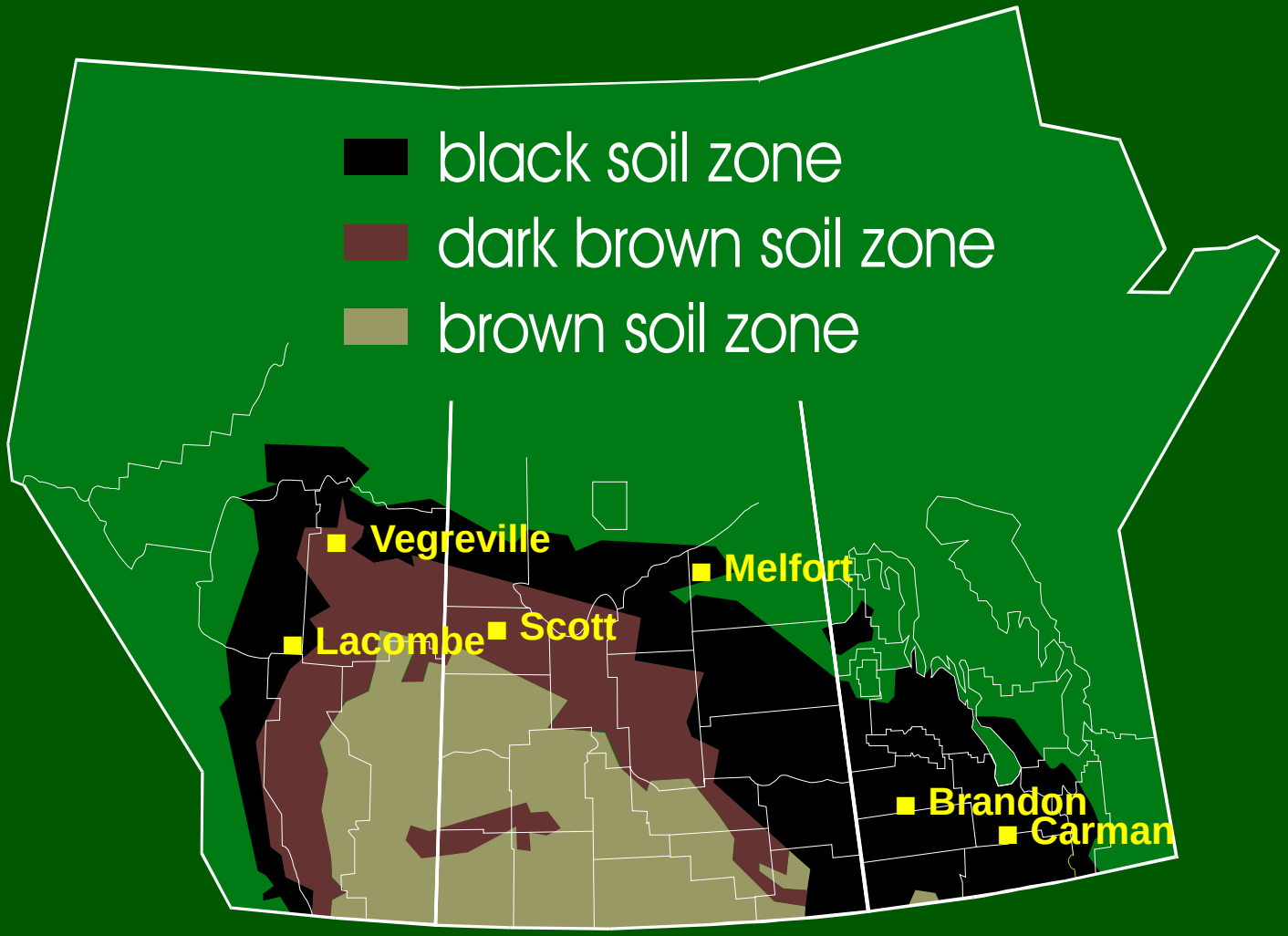
1. Non-sprayed control
2. Headline @2-4 leaf stage

On R cultivar (45H29)

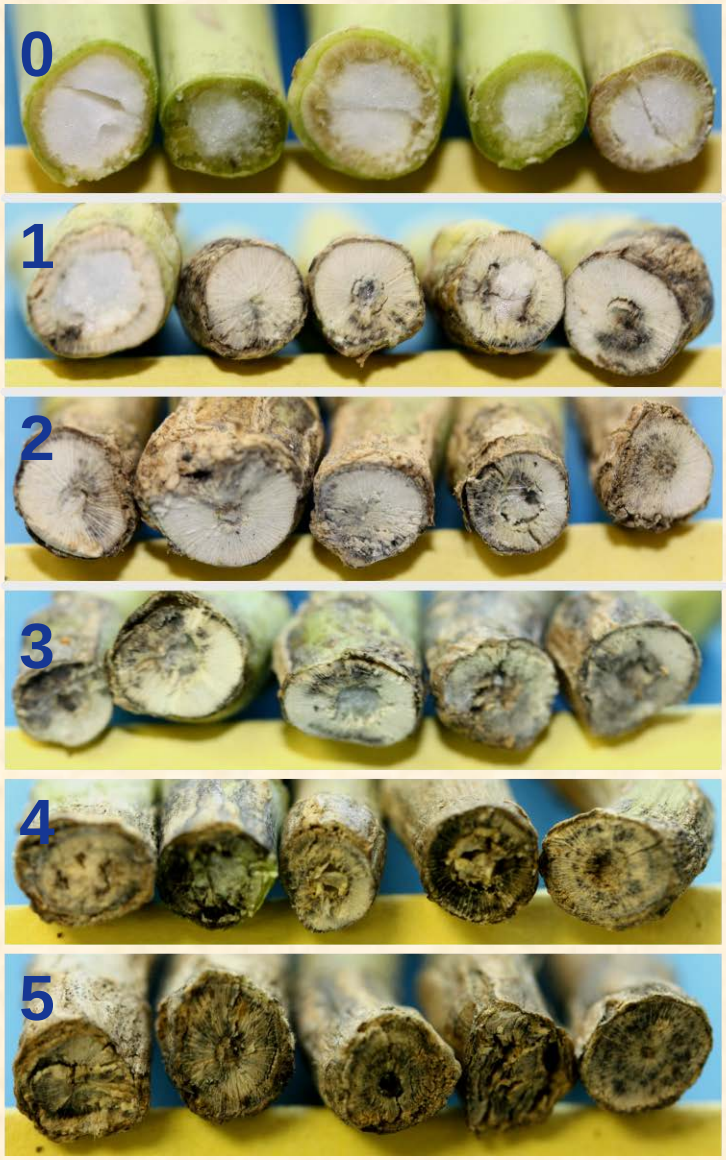
1. Non-sprayed control
2. Headline @2-4 leaf stage

All products were applied at label recommended rates

Trial locations: (2011-2014)



Trial assessment



- Disease incidence, severity were rated at near maturity
- Each replicated plots were harvested separately, seeds dried, cleaned and the yield taken for each replicate
- Stubbles were left in plots for initial inoculum in the following year
- New plots seeded adjacent to the previous plot area

Blackleg severity on S cultivar –2011 (3 sites)

Treatment	Melfort	Carman	Vegreville
Nontreated control	0.9	1.8	1.5
Headline (2-4 leaf)	0.9	0.4 *	1.2
Quadris (2-4 leaf)	0.9	0.6 *	1.1
Tilt (2-4 leaf)	1.1	2.7	1.4
Quilt (2-4 leaf)	0.5	1.0	1.4
Headline (rosette)	0.9	1.5	1.2
Tilt (2-4 L) + Headline (rosette)	0.6	1.2	1.1
Headline (2-4 L) + Tilt (rosette)	0.6	0.7 *	1.2

***** Significant at *P*=0.05 (Dunnetts' test)

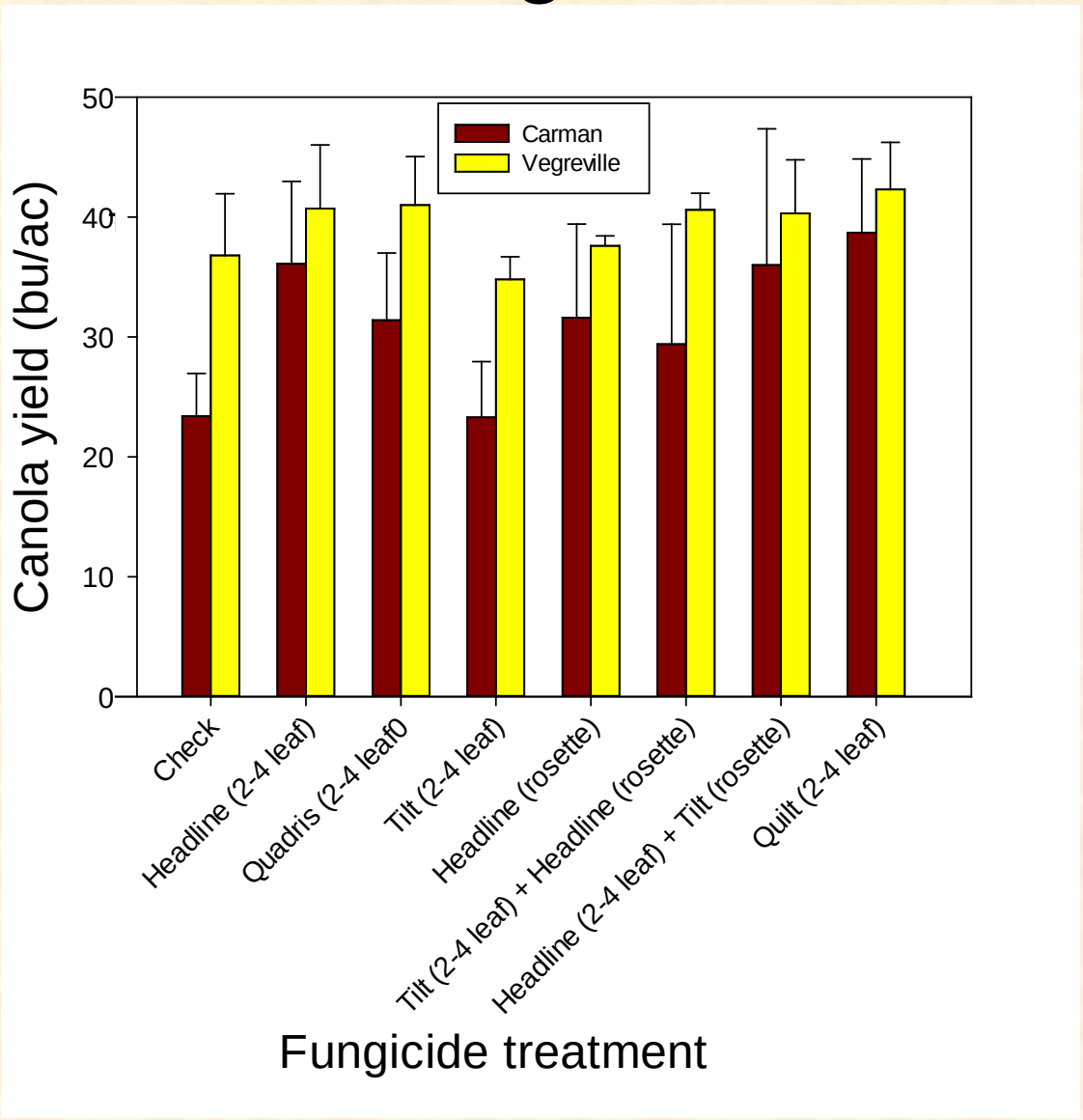
Blackleg severity on S cultivar –2012 (5 sites)#

Treatment	Brandon	Carman	Vegreville
Nontreated control	1.9	2.9	3.4
Headline (2-4 leaf)	1.5	0.9 *	2.2 *
Quadris (2-4 leaf)	1.4	1.6 *	1.7 *
Tilt (2-4 leaf)	1.7	2.3	2.5
Quilt (2-4 leaf)	1.5	2.1	1.7 *
Headline (rosette)	2.5	2.3	1.7 *
Tilt (2-4 L) + Headline (rosette)	2.6	2.6	1.7 *
Headline (2-4 L) + Tilt (rosette)	1.5	1.2 *	1.8 *

The disease severity at Melfort and Scott sites (SK) was <1

***** Significant at *P*=0.05 (Dunnetts' test)

Yield of S cultivar was not affected by fungicide treatments (2011)



- No substantial increase in yield observed with any of the fungicide treatments.
- High variability with yield data

Yield (bu/ac) **of S cultivar was not affected by fungicide treatments (2012)**[#]

Treatment	Brandon	Carman	Vegreville
Non-treated control	10.6	24.1	21.3
Headline (2-4 leaf)	10.0	25.0	27.6
Quadris (2-4 leaf)	12.7	27.4	23.5
Tilt (2-4 leaf)	9.7	22.7	23.0
Quilt (2-4 leaf)	12.3	33.0	27.5
Headline (rosette)	10.9	28.0	26.9
Tilt (2-4 leaf) + Headline (rosette)	10.5	24.0	25.0
Headline (2-4 leaf) + Tilt (rosette)	11.3	29.1	24.2

[#] The disease severity at Melfort and Scott sites (SK) was <1. Stats were based on Dunnetts' test at $P = 0.05$.

Fungicides did not improve the yield (bu/ac) **of R/MR canola cultivars**

(Cultivar) **Treatment**	**Brandon 2012** #	**Carman 2011**#	**2012**	**Vegreville 2011**	**2012** #
(45H29 -R)					
Nontreated	17.4	62.5	43.9	65.7	47.2
Headline	19.3	54.4	50.9	61.7	44.7
(43E01 -MR)					
Nontreated	13.5	42.6	36.8	47.0	36.3
Headline	13.6	38.7	32.1	52.8	30.8

The fungicide treatment reduced blackleg substantially (Dunnetts' test, *P*=0.05)

Summary

- *Av1, Av3, Av9, AvLep1 & AvLep2* genes showed low frequencies in the *L. maculans* population, so *Rlm1, Rlm3, Rlm9, LepR1, & LepR2* genes are ineffective
- Regional variation in *Av* genes –cultivar selection (if *R* genes are known)?
- Most cultivars/lines carry *Rlm3.* Other *R* genes are rare, showing limited diversity of *R* genes in canola germplasm
- A few lines carry multiple *R* genes (up to 4)

Summary …….continues

- Rotation of *R* genes may be a challenge –lack of diversity
- Quantitative *R* genes may be important, but poorly understood
- Early spray (2-4 leaf stage) with Headline/Quadris reduced blackleg 3 out 5 site-years on S cultivar. A late application (at bolting) would be less effective
- None of the fungicide treatments increased canola yield substantially, regardless of host resistance

Acknowledgements

Technicians, graduate students, coop students at AAFC, Saskatoon/Melfort/Scott, SK; Brandon, MB; Lacombe, AB, University of Manitoba, and Alberta Innovates provided technical assistance

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