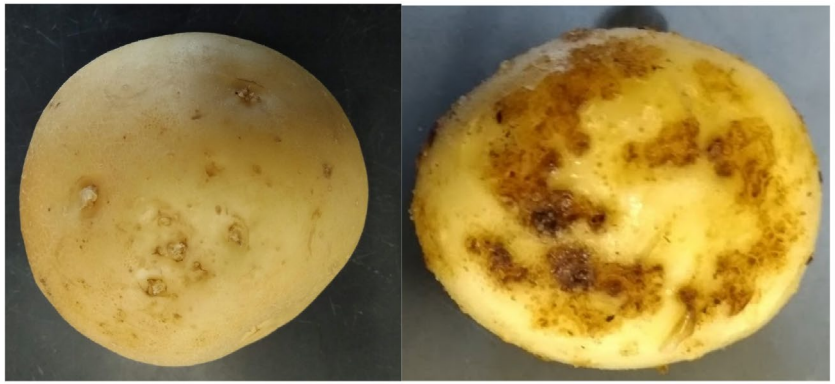
Streptomyces bacteria in potato production – from pathogens to beneficial microbes

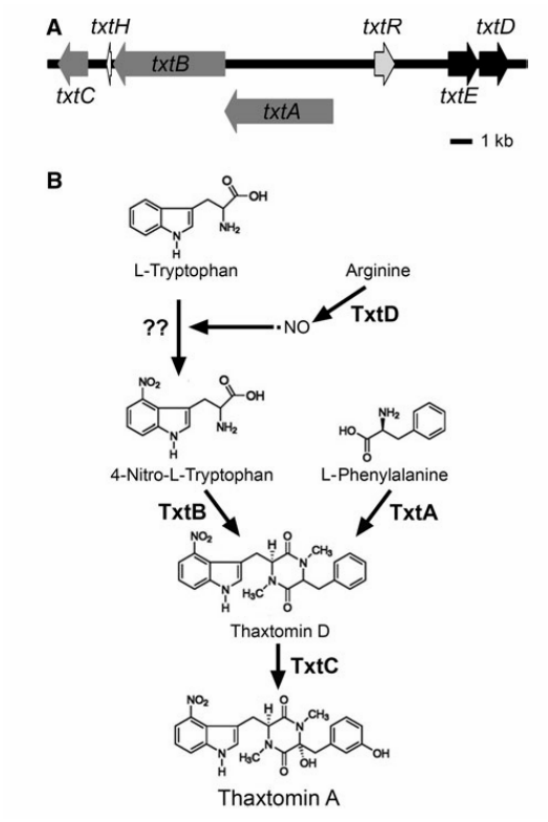
Christopher Clarke
WA/OR potato meeting
January 22nd, 2020



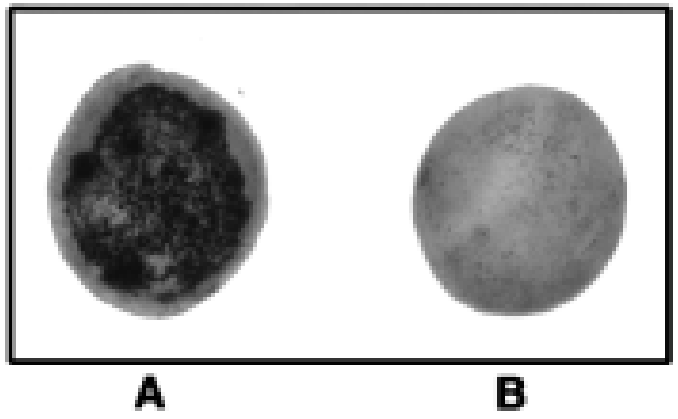
No Lesions Superficial Lesions

Raised Lesions Pitted Lesions

The toxin thaxtomin A is the primary known virulence determinant for common scab pathogens



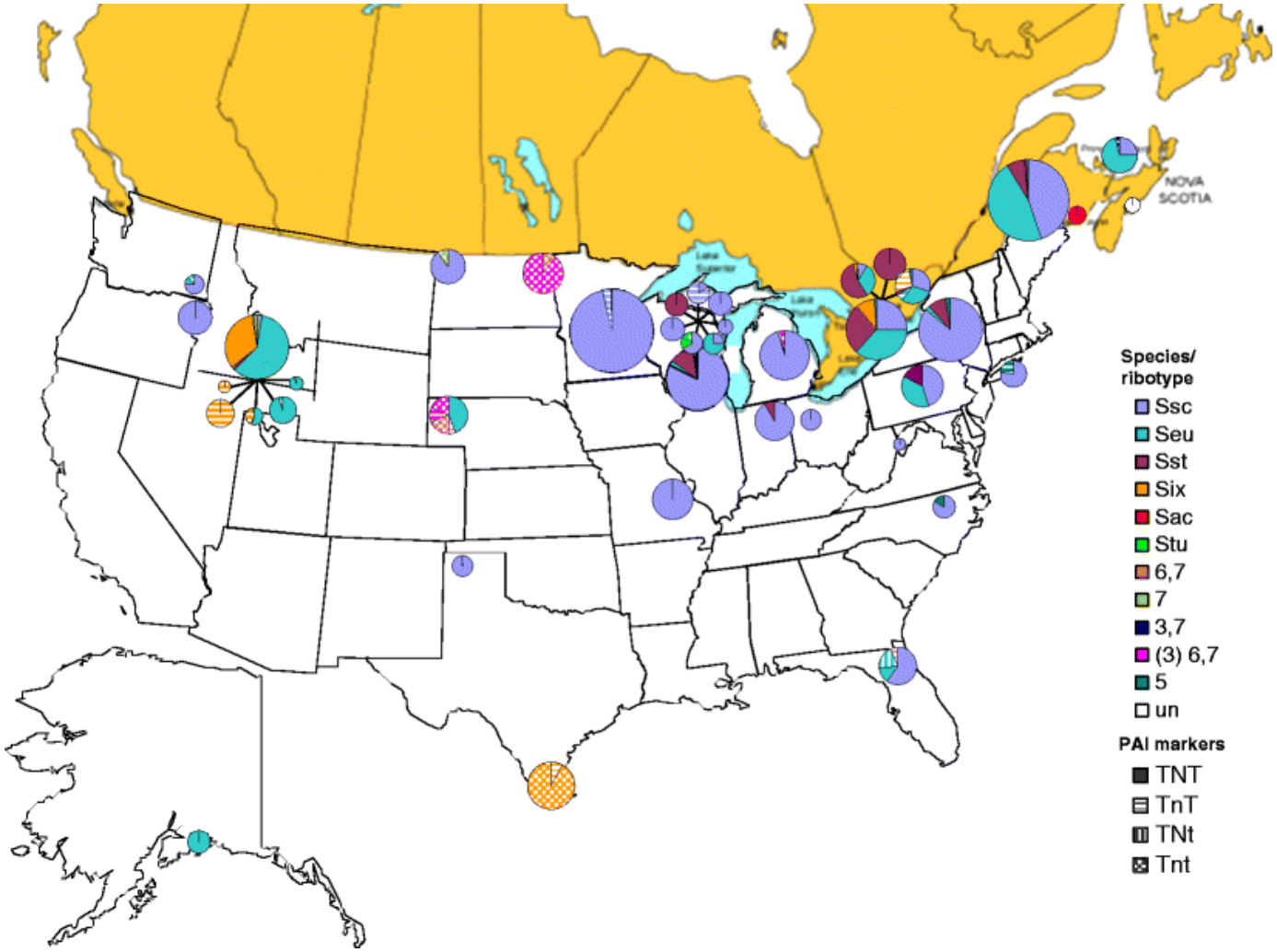
Bignell et al. What does it take to be a plant pathogen: genomic insights from Streptomyces species. *Antonie van Leeuwenhoek*. 2010.



Burkhalid and Loria. Cloning and Expression of a Gene from Streptomyces scabies Encoding a Putative Pathogenicity Factor. *J. Bacteriology*. 1997.

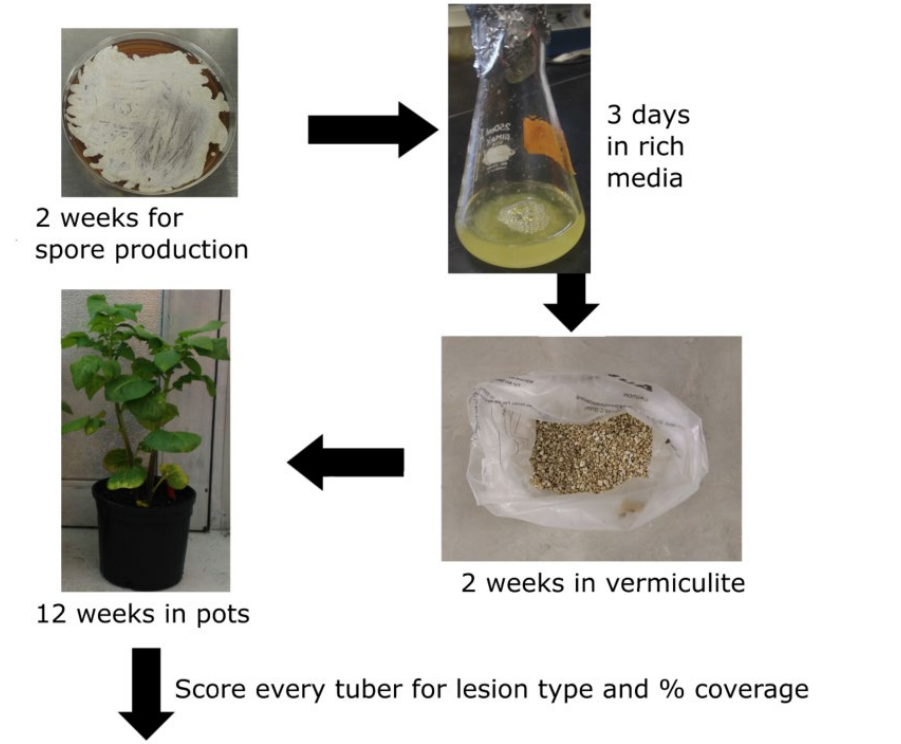
The ARS Genetic Improvement for Fruits and Vegetables lab has a large and diverse collection of *Streptomyces* isolated from tubers

Figure from: Wanner. AJPR. 2009.



First question: Is cultivar resistance to common scab dependent on the pathogen species?

Test 3 common scab pathogens for virulence on 55 cultivars/ populations of potato in a greenhouse assay



The *Streptomyces* pathogen matters

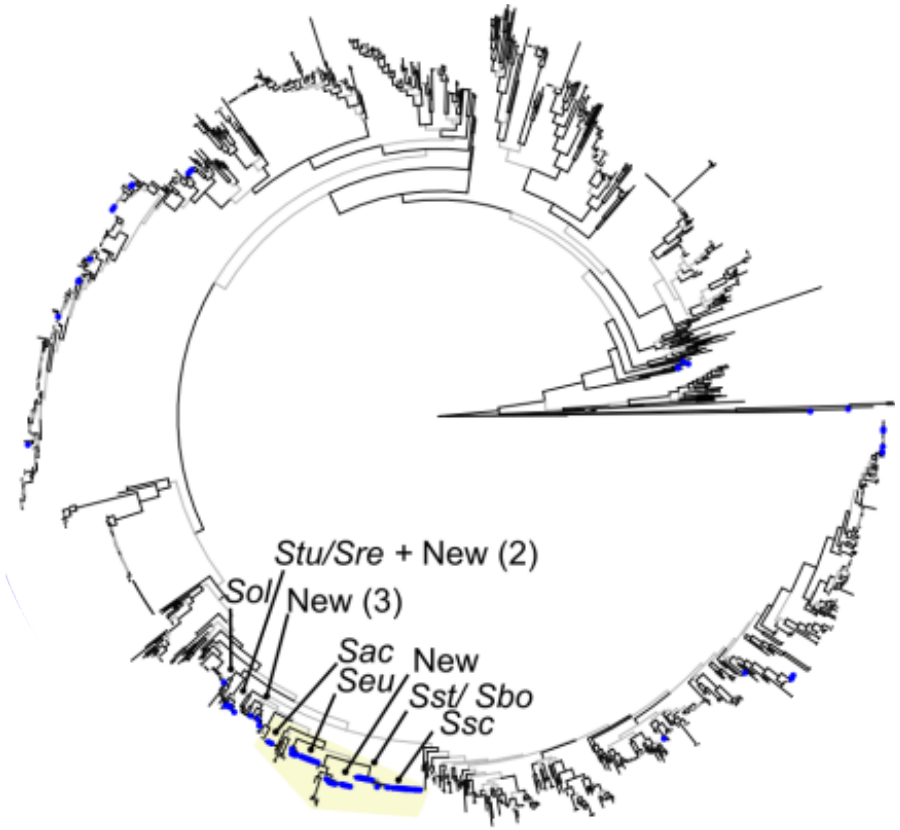
Analysis of Variance of a mixed linear model; last column gives percent of total variation

Fixed effects	Sum Sq.	Num. df	Den. df	F value	P	Percent total variation
cultivar	11.7	19	148.9	4.4	< 0.0001	9.51
pathogen	10.7	1	161.7	75.4	< 0.0001	23.22
year	0.3	1	163.4	1.8	0.1833	0.00
cultivar*pathogen	5.6	19	146.2	2.1	0.0078	7.42
cultivar*year	2.0	19	143.6	0.7	0.7642	0.00
pathogen*year	0.4	1	148.7	3.1	0.0789	1.08
Random effects						
Plant (Pot) Discreteness error						9.89 32.66
Residual (tuber)						16.22

Matt Kramer, ARS

Clarke et. al. 2019. *Phytopathology.* 109 (9), 1544-1554.

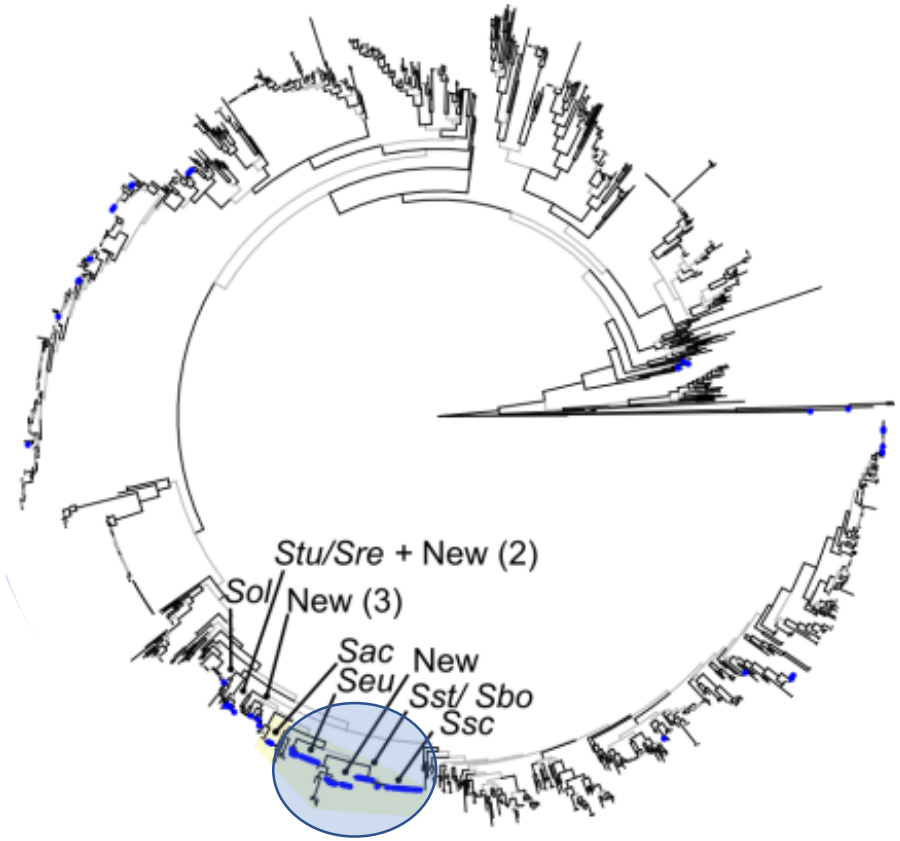
Developing a phylogenetic framework describing the diversity of potato-associated *Streptomyces*

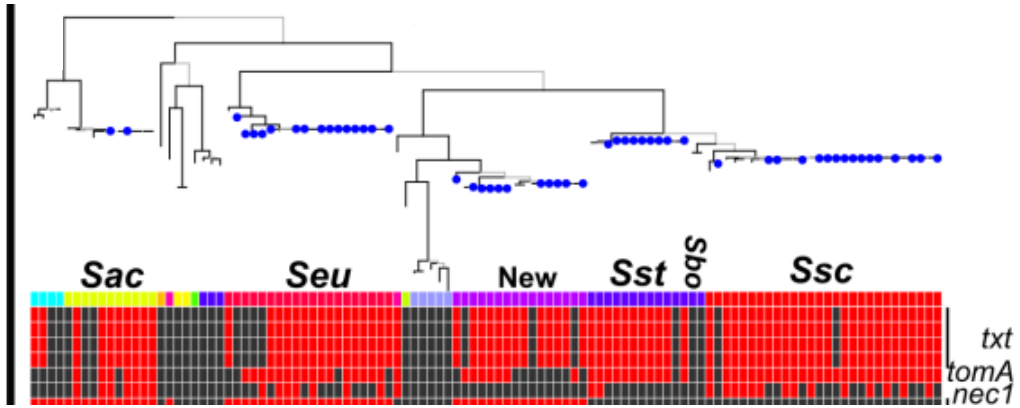


We genome sequenced 150 potato-associated *Streptomyces* from our culture collection

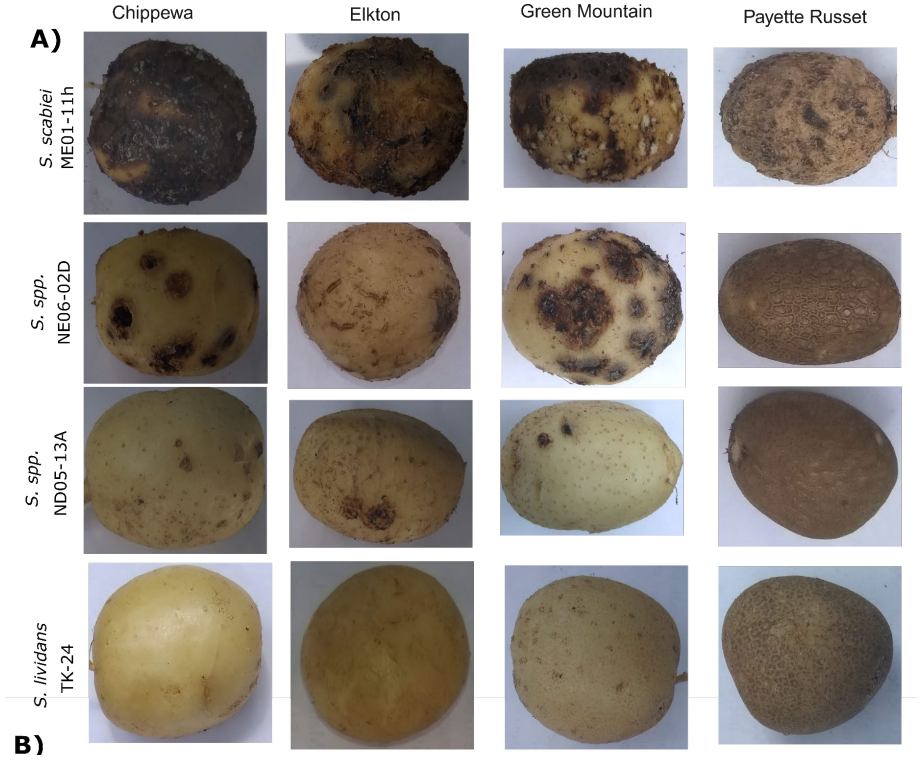
Jeff Chang and Alexandra Weisberg (Oregon State University)

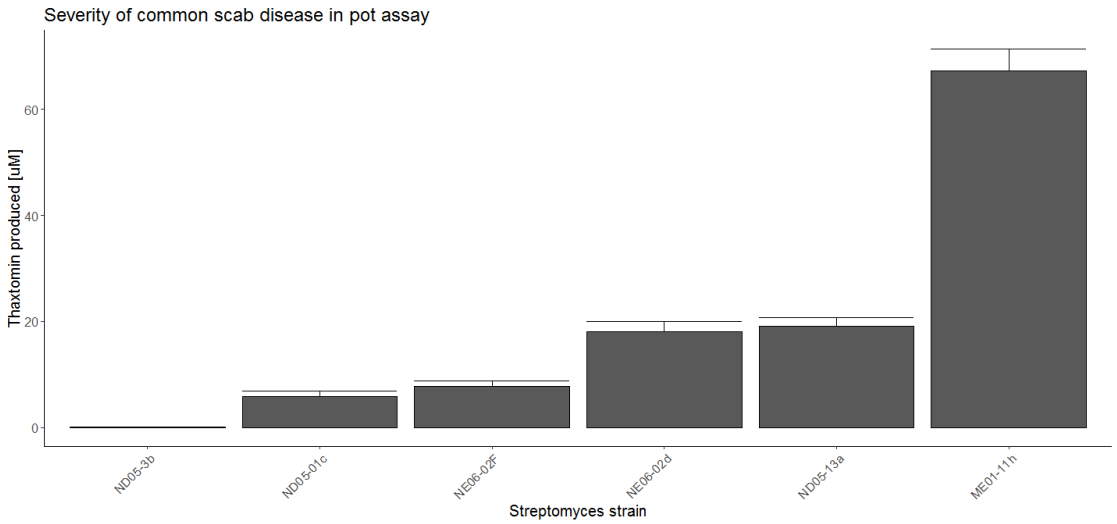
Developing a phylogenetic framework describing the diversity of potato-associated *Streptomyces*





Variable pathogenicity within a new species group





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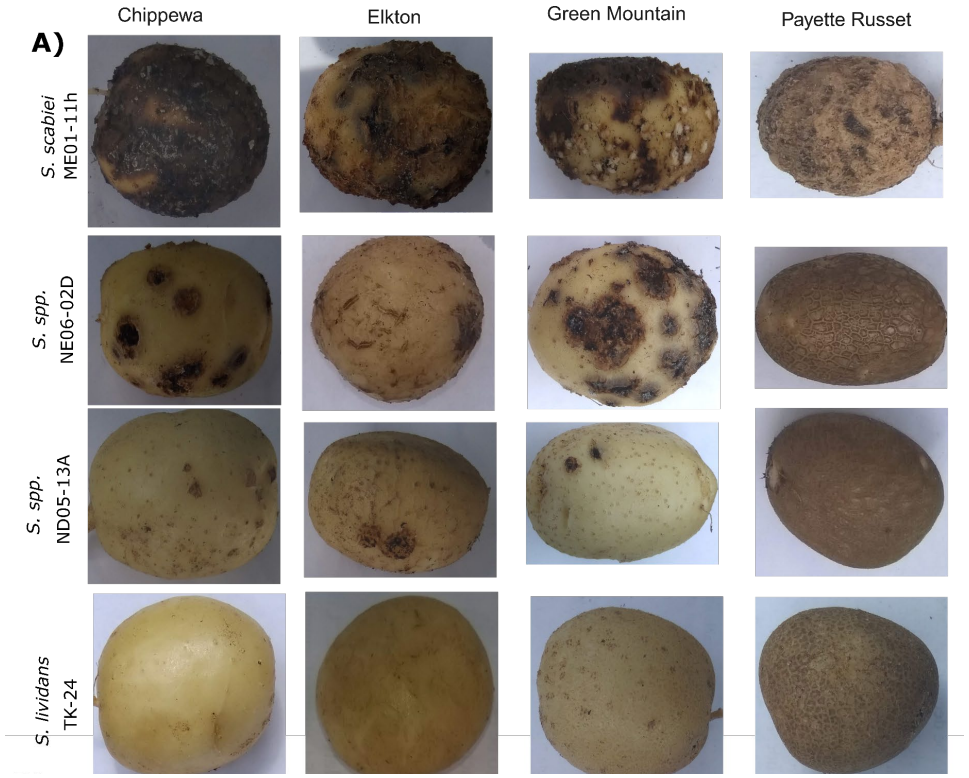
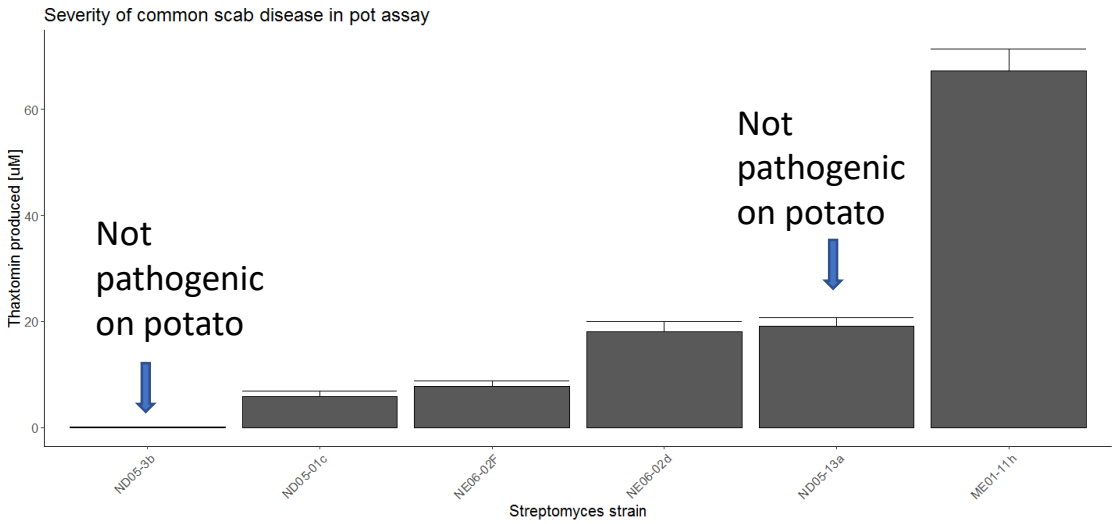
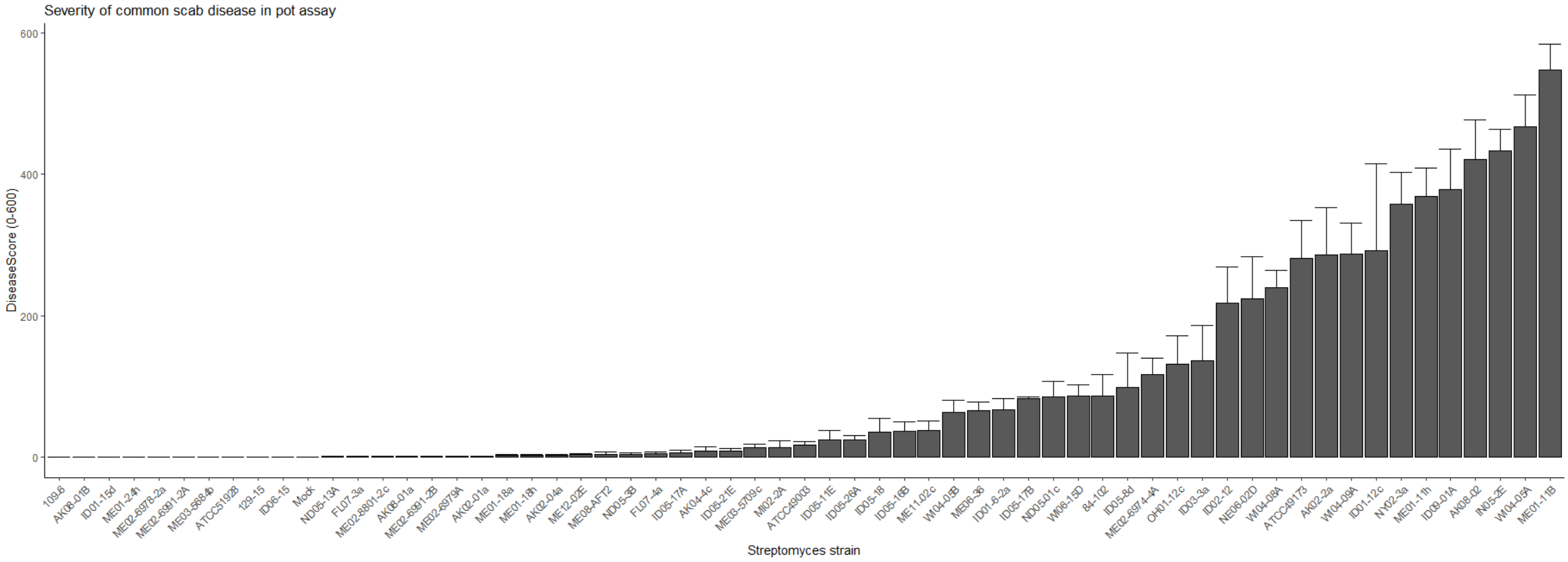




Pathogenicity of various *Streptomyces* on potato



- **<u>Notes on the diversity of *Streptomyces* pathogens:</u>**
- Understanding the local *Streptomyces* population is critical
- We still know relatively little about the extent of the diversity of common scab pathogens
- New pathogens can emerge through acquisition of the thaxtomin biosynthetic cluster
- Will disease management be effective against all common scab pathogens?

Control of common scab – No promising options right now…

- Genetic – some quantitative resistance loci have recently been identified. Very unlikely to find dominant, qualitative *R* genes. We're working on identifying genes critical for potato sensitivity to thaxtomin.
- Cultural – Low soil pH? High soil moisture.
- Chemical – Low-dose application of 2,4-D previously shown to reduce common scab in a few select cultivars of potato.

Does low-dose 2,4-D treatment manage common scab disease in the field?

- Incomplete split-plot design
- Control (0.5% Tween-80) vs. treatment (0.5% Tween-80 + 1% label rate 2,4d)
- Barrier rows between plots to minimize herbicide drift effect
- Amine formulation of 2,4-D

Treatment with low-dose 2,4-D reduces the severity of common scab symptoms

Disease score (2018 ME):

	Sum Sq	Mean Sq	NumDF	DenDF	F value	Pr(>F)	
Genotype	144.6	28.9199	5	67.869	21.005	1.27E-12	***
Treatment	16.945	8.4724	2	62.57	6.1536	0.003633	**
PC2[1]	19.87	19.87	1	69.724	14.432	0.000307	***
Y position	17.753	17.7532	1	62.758	12.8945	0.000647	***
Moisture 8.27	12.447	12.4467	1	66.945	9.0403	0.003717	**
Genotype:Treatment	4.538	0.756	6	60.23	0.549	0.769	

Brent Dyer, A.J. O'Donnell, and Kathy Haynes (ARS)

Using non-pathogenic *Streptomycetes* as biocontrol strains for common potato pests

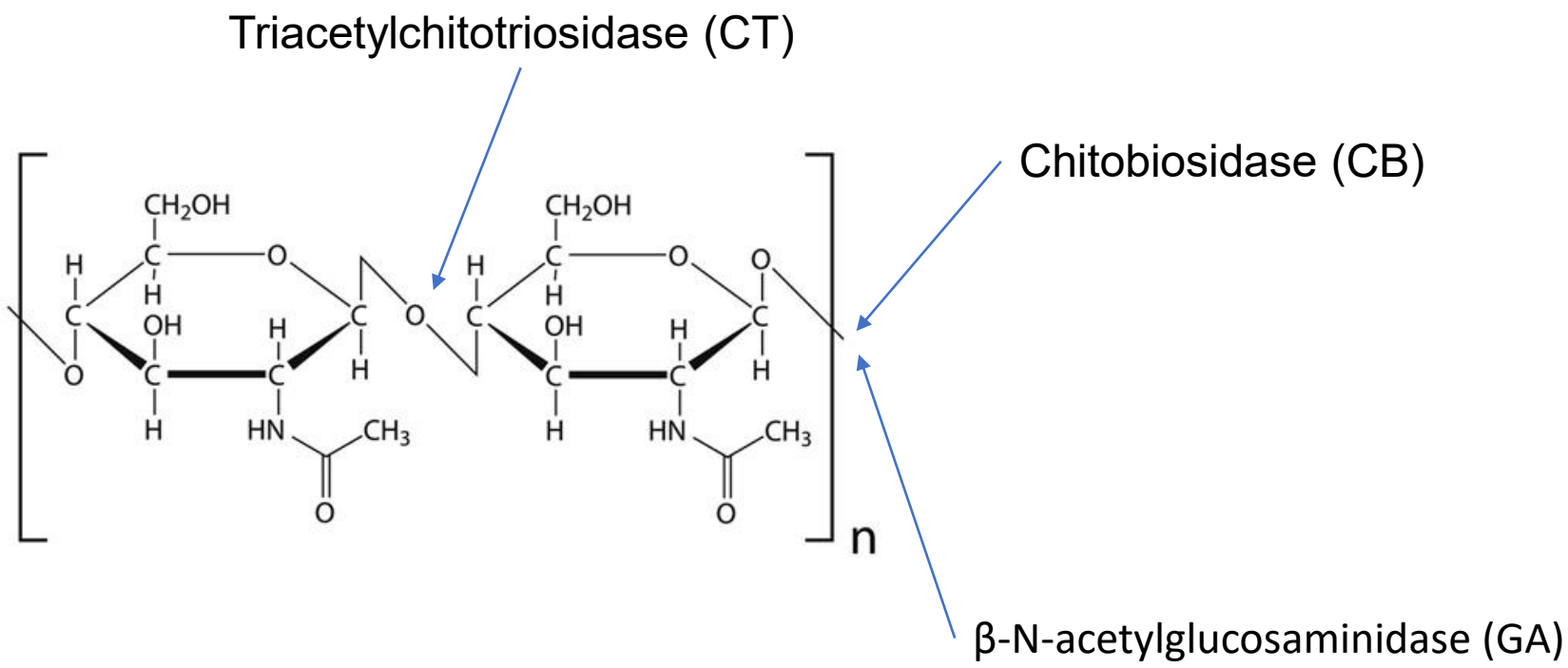
<u>The potential value of *Streptomyces* for control of potato tuber diseases:</u>

- Fewer effective chemical treatments for control of soilborne diseases than foliar diseases
- *Streptomyces* genus is prevalent in most soil types – well adapted to thrive in soil.
- *Streptomycetes* in the ARS GIFVL culture collection were isolated from tubers suggesting that they can thrive in close association with tubers.
- *Streptomyces* are prolific producers of antimicrobial compounds (source of over 2/3 of clinical antibiotics).

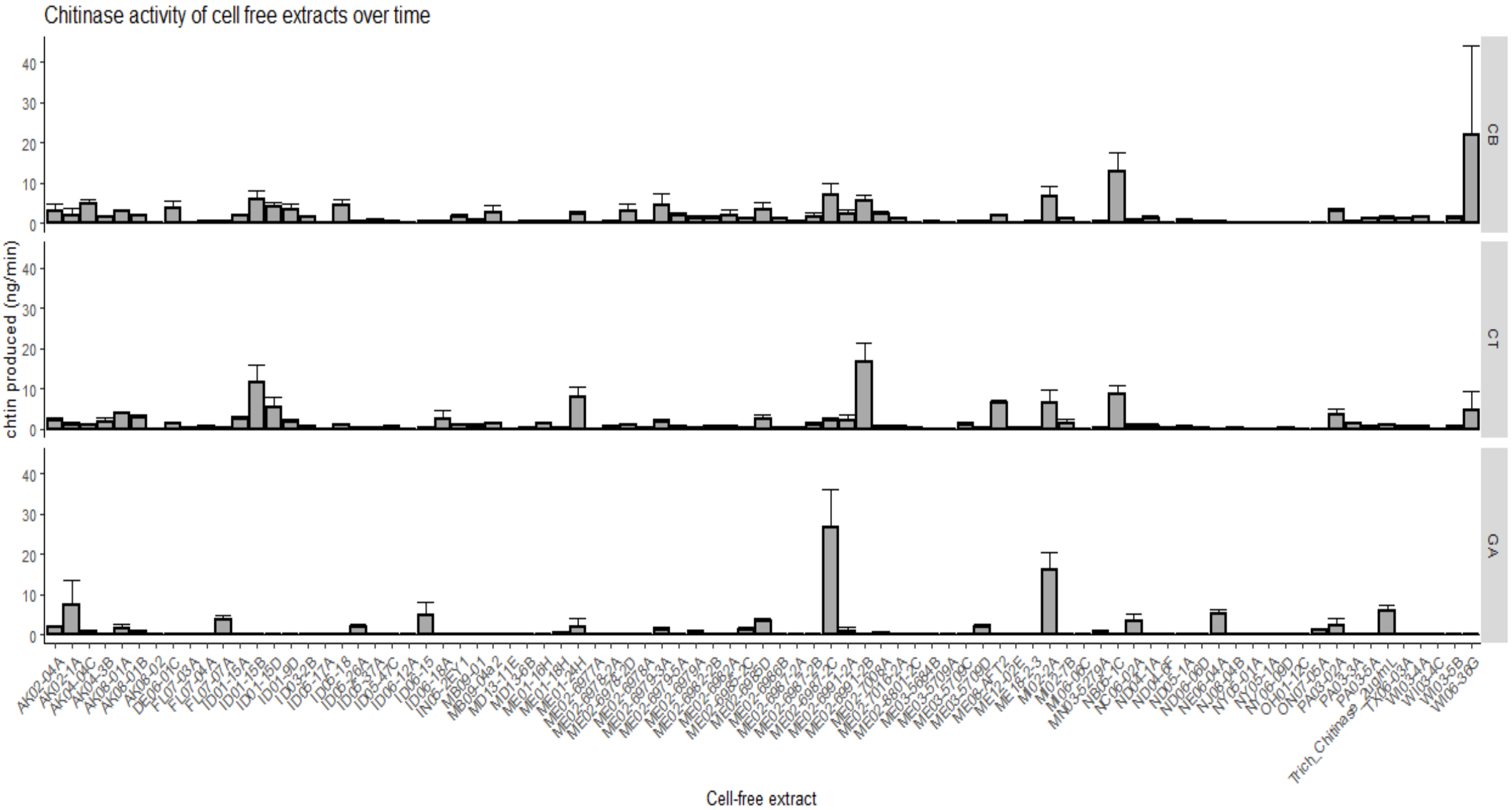
Brad Geary, BYU

Cynthia Gleason, WSU

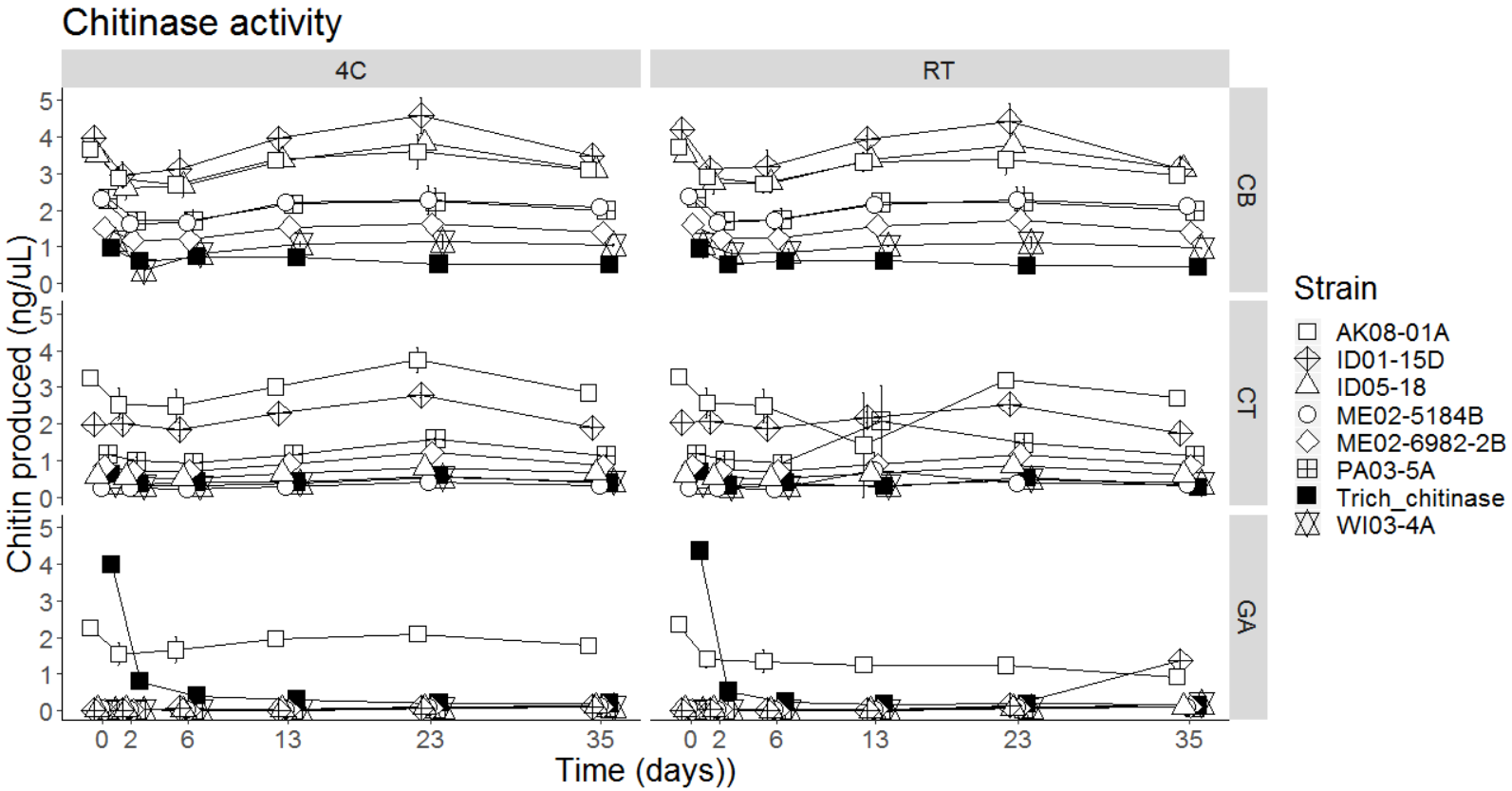
Different types of chitinase activity



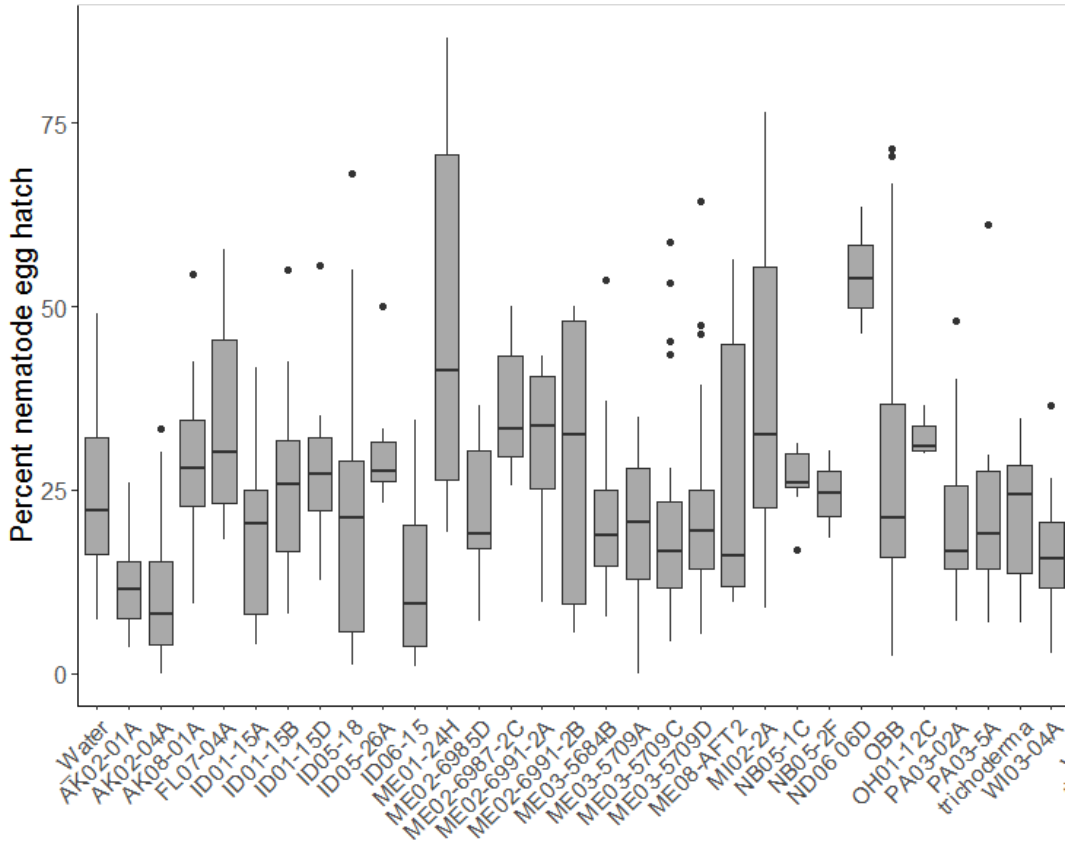
Measured all three types of chitinase activity from 90 Strep strains (at least two biological replicates and two technical replicates per strain-substrate combination).

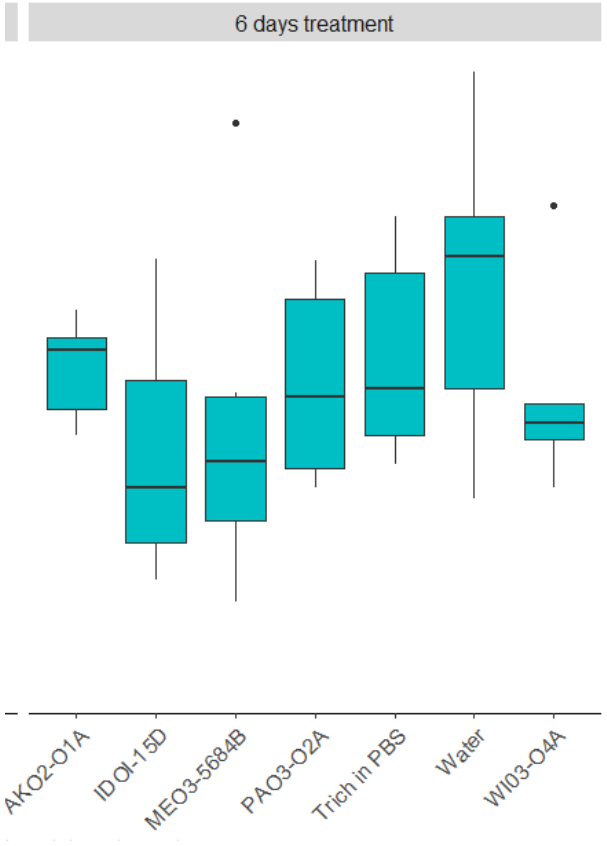

Chitinase activity of cell free extracts over time
chtin produced (ng/min)
CB
CT
GA
Cell-free extract
Trich_Chitinase 2ug/mL

Stability of *Streptomyces* chitinase

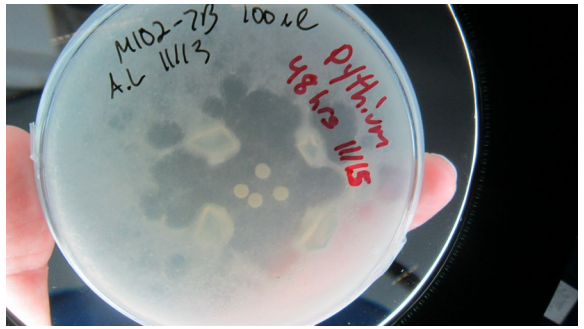


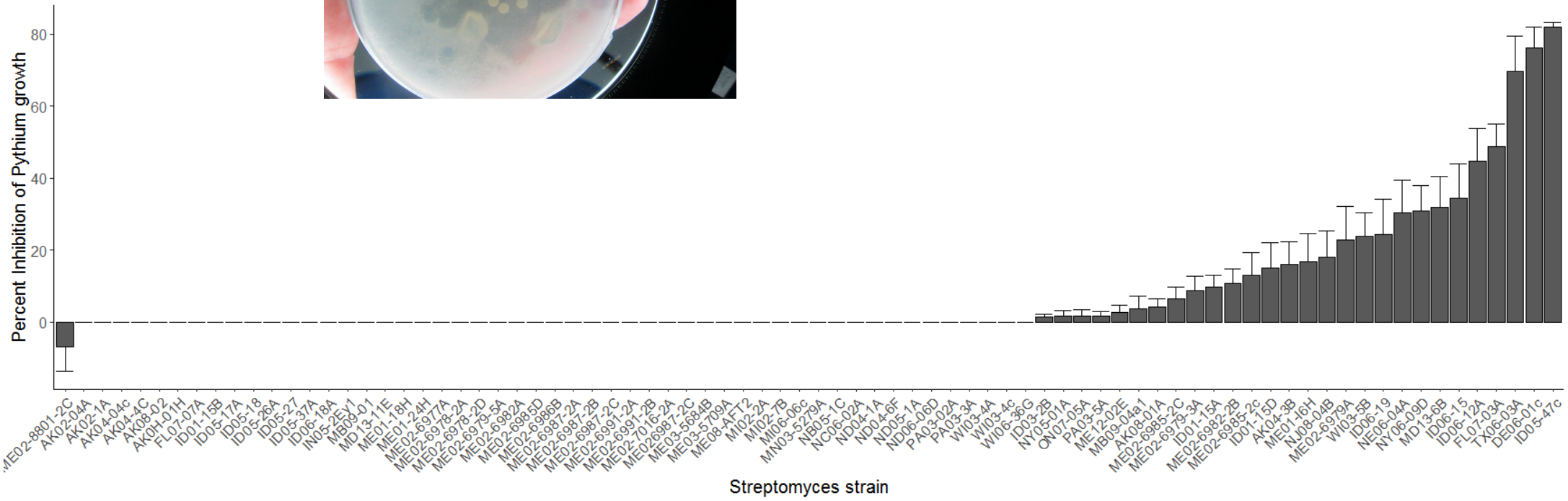
Streptomyces cell-free extracts degrade *M. chitwoodii* eggs





Streptomyces control of *P. ultimum*





Other pathogens being tested: Rhizoctonia solani and Helminthosporium solani

Acknowledgements

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Ngonda Agha
Kara LeClair