

Is quantitative resistance qualitative ?

An example with two *Alternaria* leaf blight resistant carrot genotypes and four resistance assessment techniques.

Introduction : ALB and quantitative resistance

Experiment setup

Comparing four resistance assessment methods

Conclusion



ALB and quantitative resistance



Alternaria Leaf Blight

Coalescing gray-brown lesions
Burnt aspect of severely affected leaves

Most destructive foliage disease,
caused by *Alternaria dauci*





ALB and quantitative resistance

Vertical resistance

Qualitative

Strain-specific

Well-studied
resistance mechanisms
(NBS-LRR proteins, etc.)

Mendelian determinism

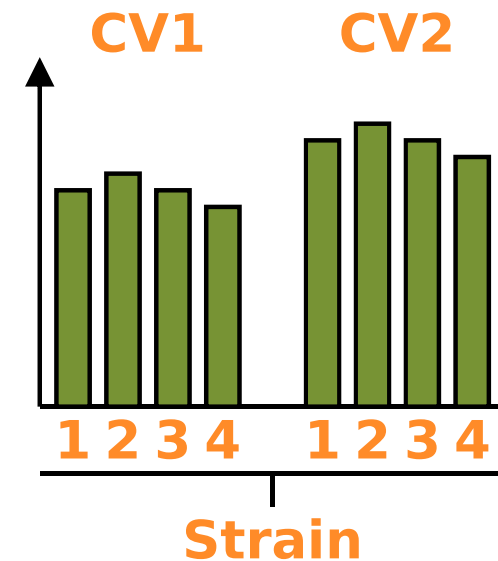
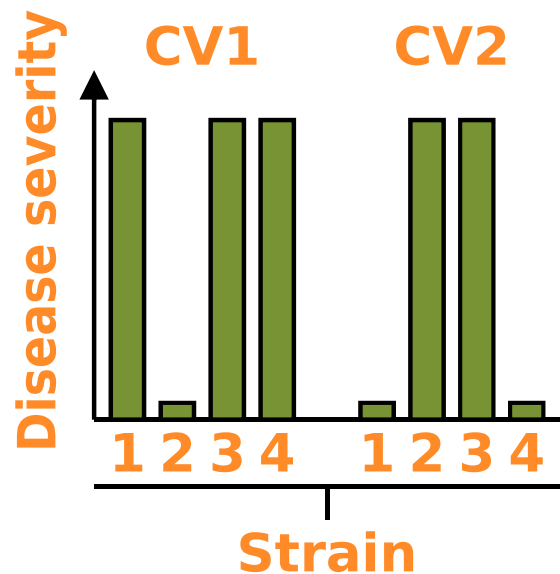
Horizontal resistance

Quantitative

Non strain-specific

Only partially uncovered
resistance mechanisms

Quantitative determinism
(QTLs)





ALB and quantitative resistance

ALB resistance is horizontal

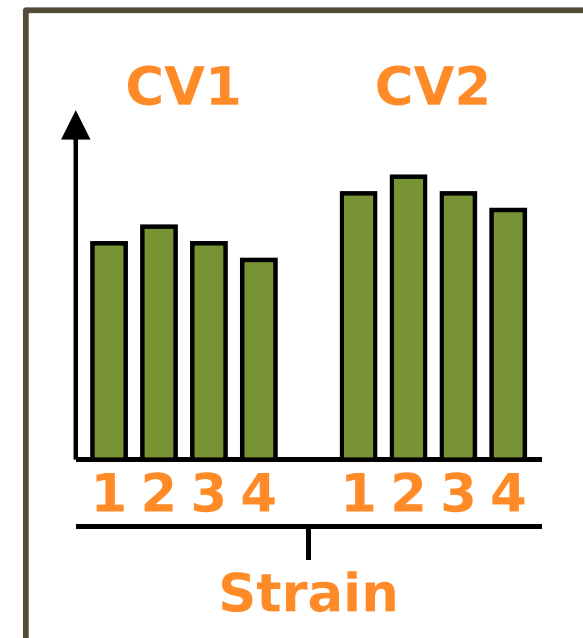
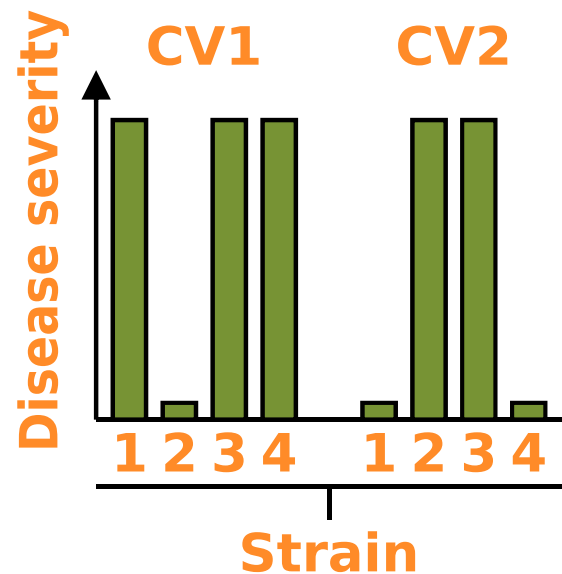
No complete resistance is known

Current cultivars show insufficient levels of resistance

→ How to measure horizontal resistance ?

Resistance sources are found in different germplasms

→ Are they really different?



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Experiment setup

ALB resistance is horizontal

→ How to measure horizontal resistance ?

- Standard visual assessment (DS evaluation)
 - Time consuming, environmental effects, evaluator effect...

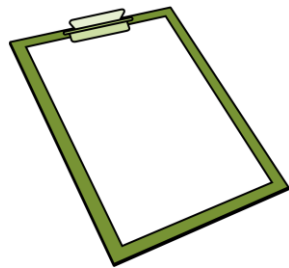
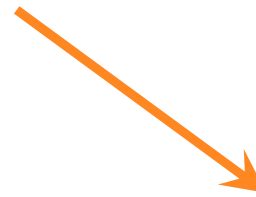
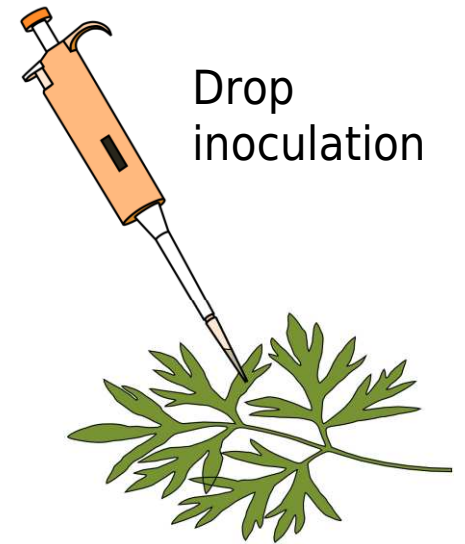
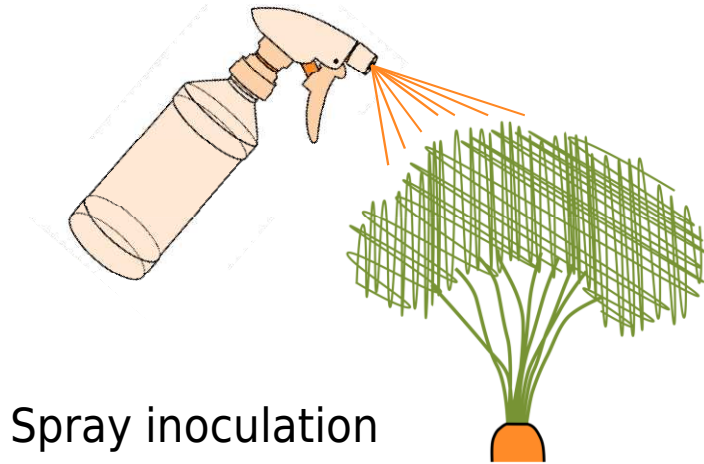
Three alternative methods tested :

- qPCR
- *In vivo* spore germination
- drop inoculation

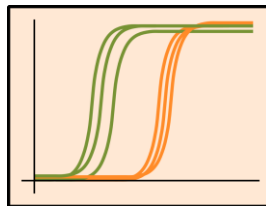
Three cultivars : • **Presto (S)** • **Bolero (R1)** • **Texto (R2)**

Two strains : • **A2** • **P2**

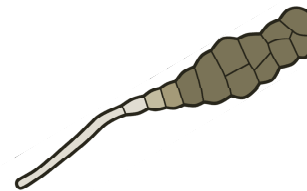
Experiment setup



Disease Severity
evaluation



Real-Time
PCR



Conidia
germination



Symptom
number

Experiment setup



Non detached leaves
Incubation chambers:
higher moisture

Pre-defined drop volume (5 μ L)
Pre-defined drop number (40)

Total number of *A. dauci*
spores is known from inoculum
concentration

Symptom counting:
A more objective notation.



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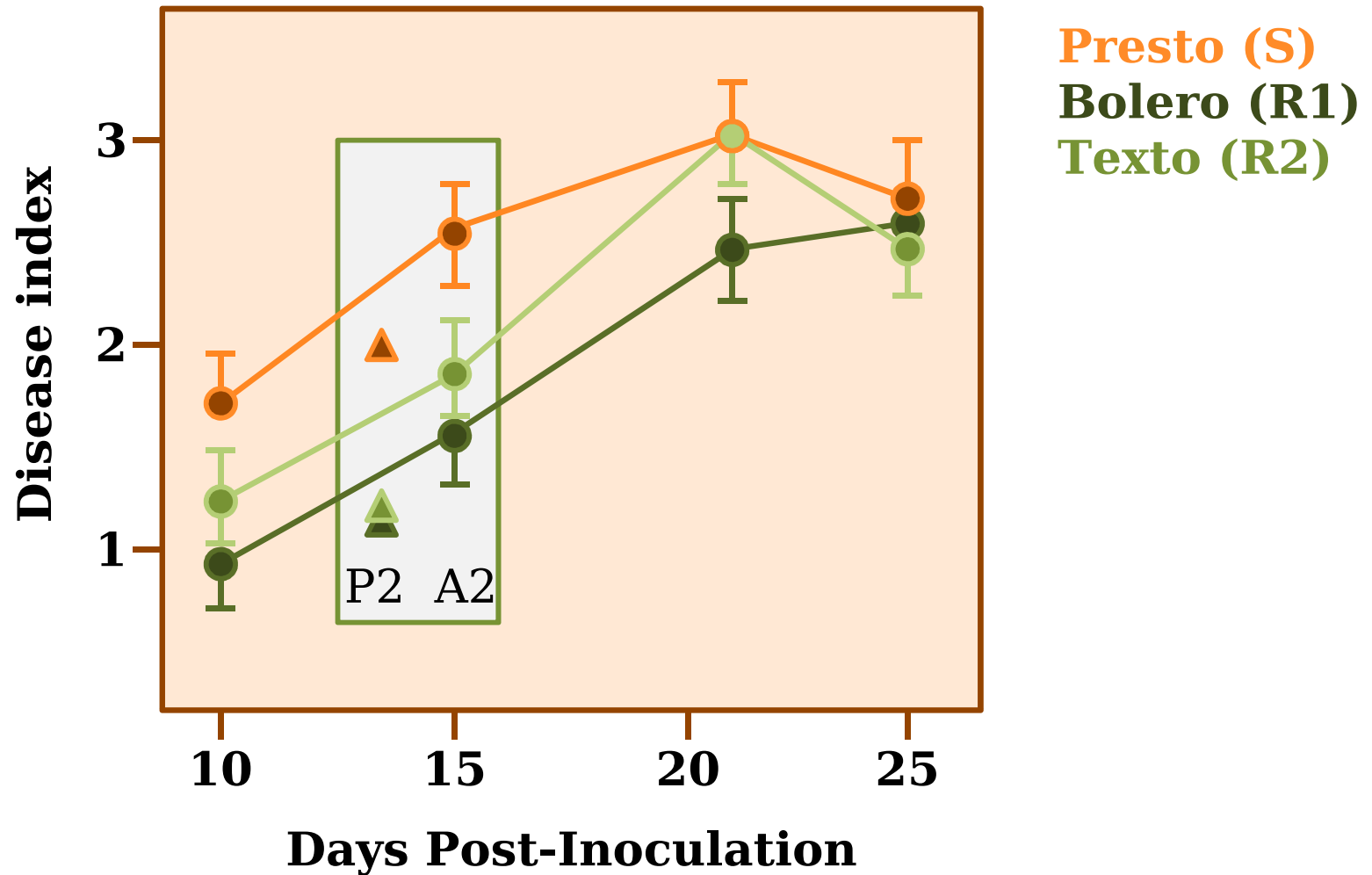
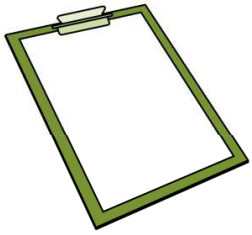
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Four evaluation methods

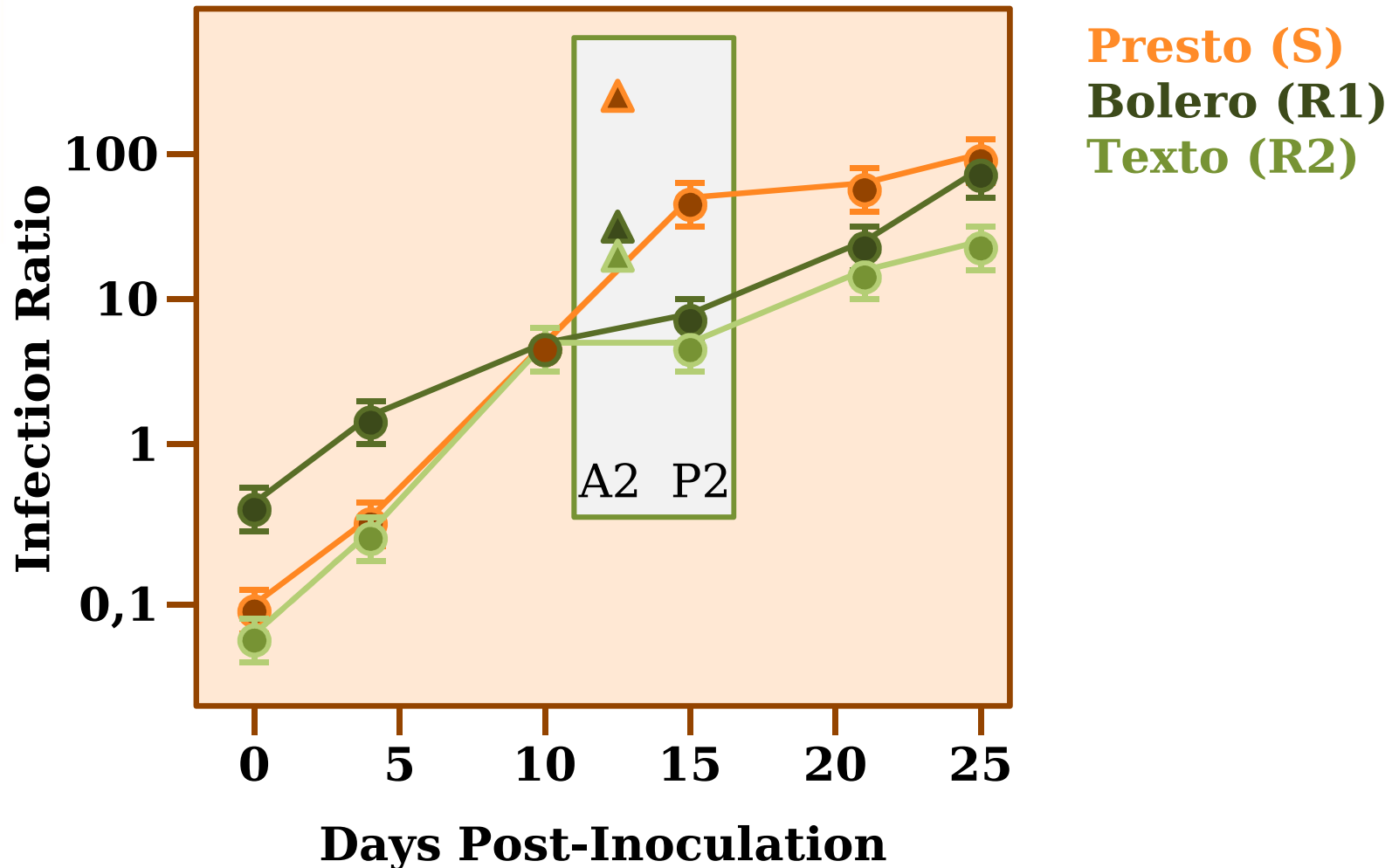
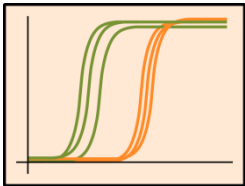


Presto always shows stronger disease indexes than resistant cultivars

Maximum difference observed at 15 dpi.

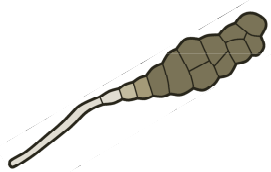
No observed strain-cultivar interaction

Four evaluation methods

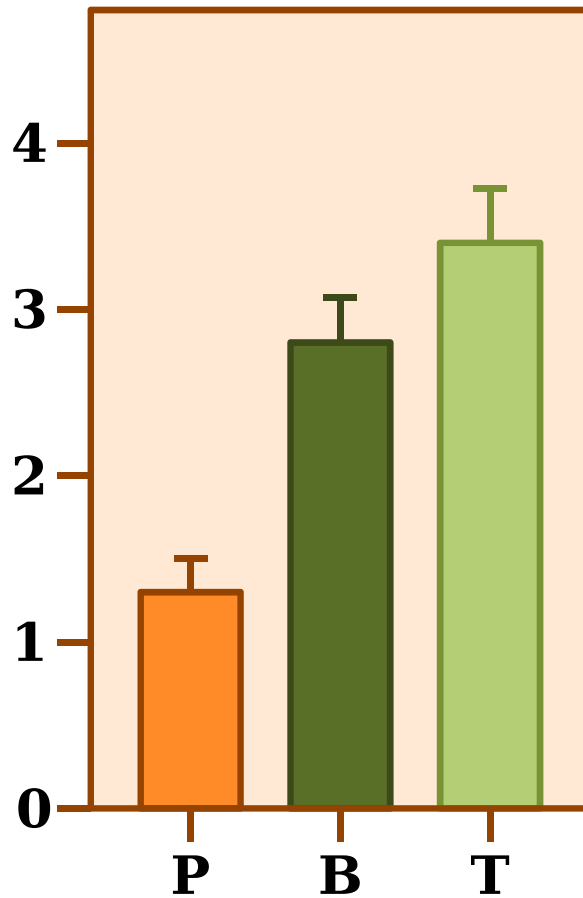


Presto shows stronger infection ratio than resistant cultivars after 10 dpi
Maximum difference observed at 15 dpi.
No observed strain-cultivar interaction

Four evaluation methods



Mean Germ tube Number

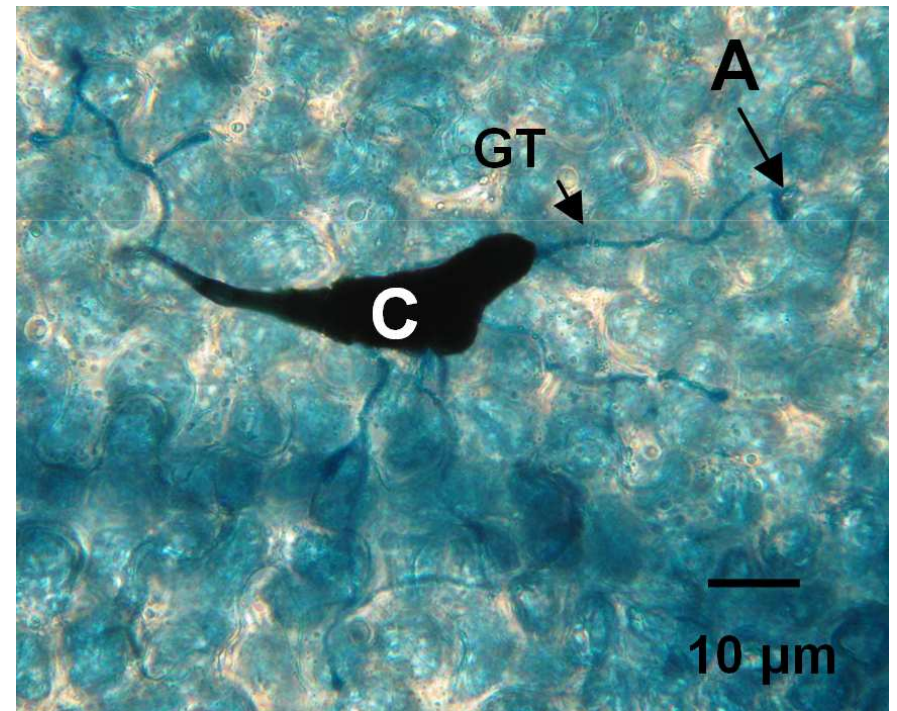


Presto (S)
Bolero (R1)
Texto (R2)

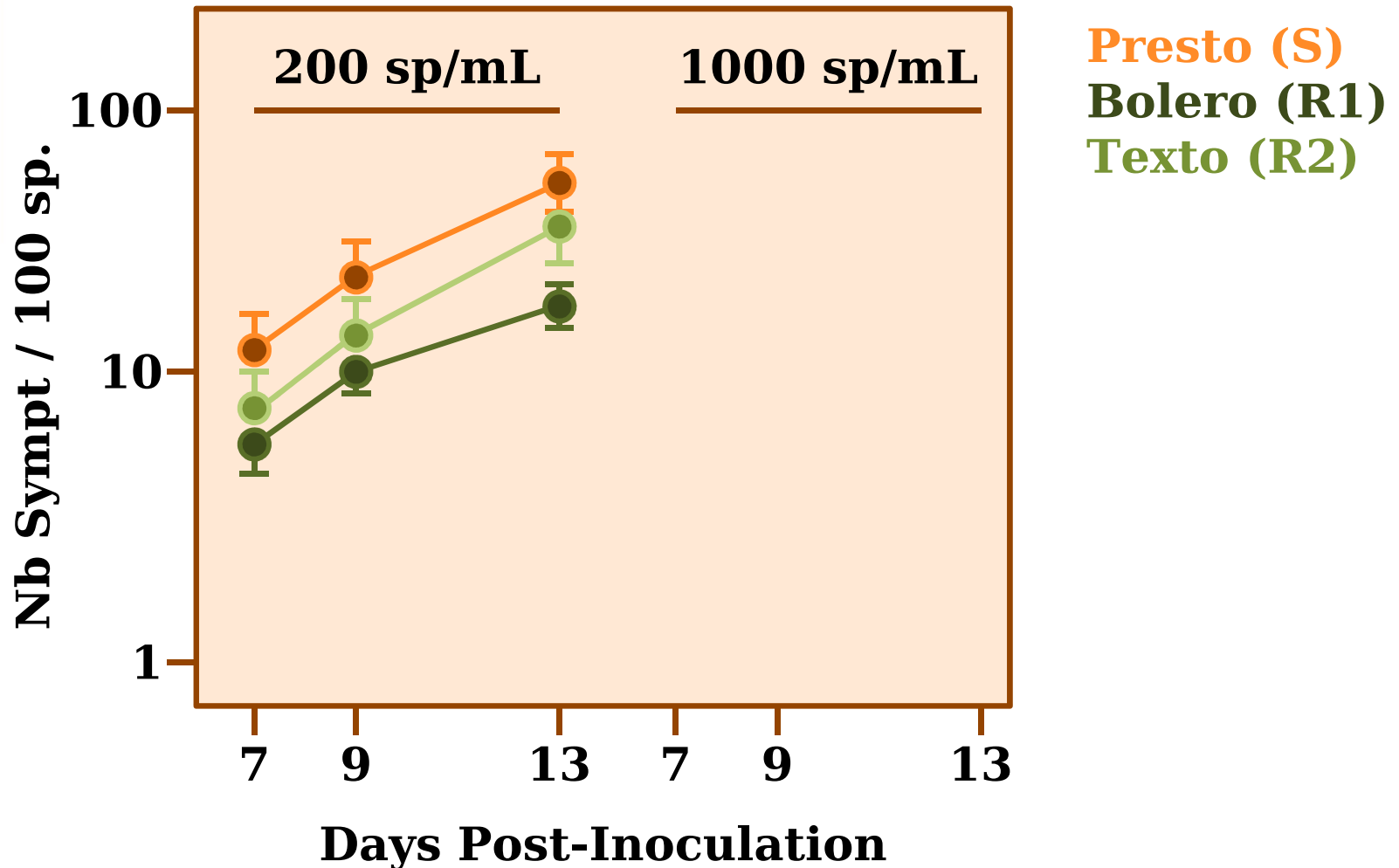
Germination rate $\approx 100\%$,
 \forall tested cultivar

large germ tube numbers on resistant cultivars = failed penetration attempts?

Example on Texto : 7 germ tubes



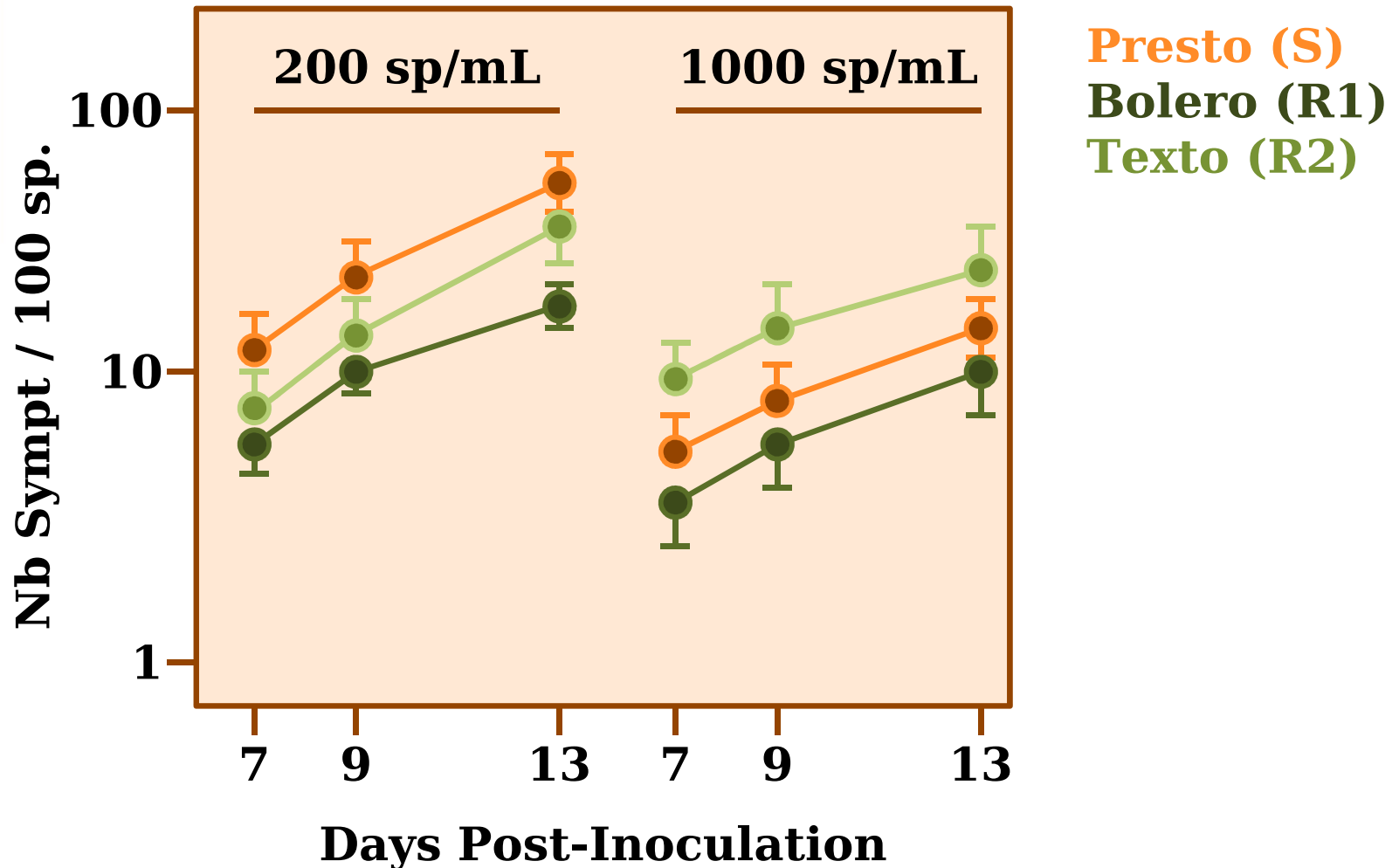
Four evaluation methods



Fine tuning of the experiment: Spore concentration, inoculation date, notation date, etc.

200 sp/mL: Resistance is detectable in Bolero compared with Presto. Texto shows intermediate resistance levels

Four evaluation methods



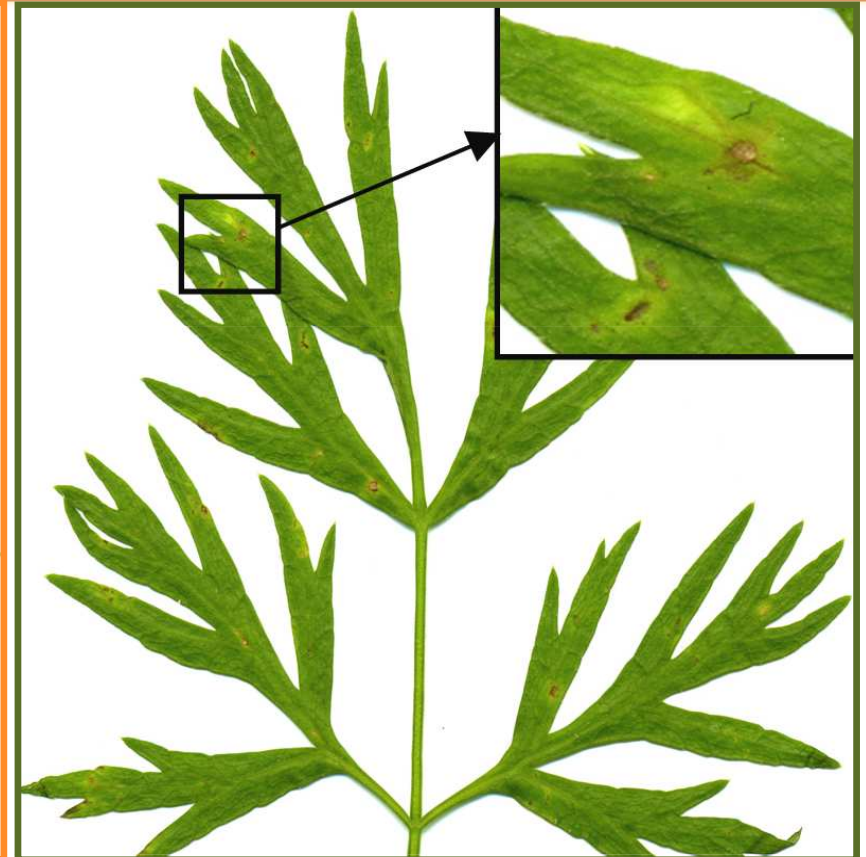
Fine tuning of the experiment: Spore concentration, inoculation date, notation date, etc.

1000 sp/mL quite different results: More symptoms in Texto than Presto! What happened?

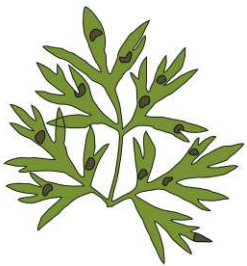
Four evaluation methods



Presto

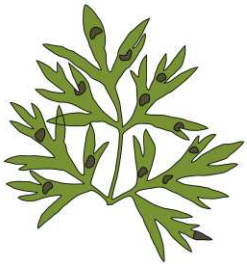


Bolero



13 dpi, 1000 sp/mL

Four evaluation methods



Texto

13 dpi, 1000 sp/mL

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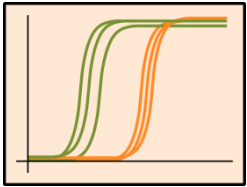
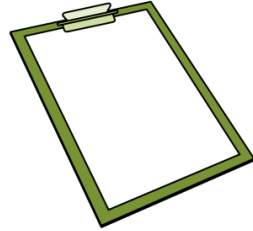
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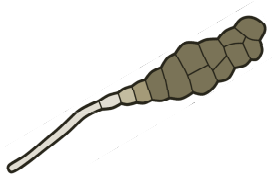
Comparing four resistance assessment methods

Conclusion : Qualitative resistance variation

Conclusion



Better resolution
of the resistance level



Faster evaluation
of resistance level (1dpi)



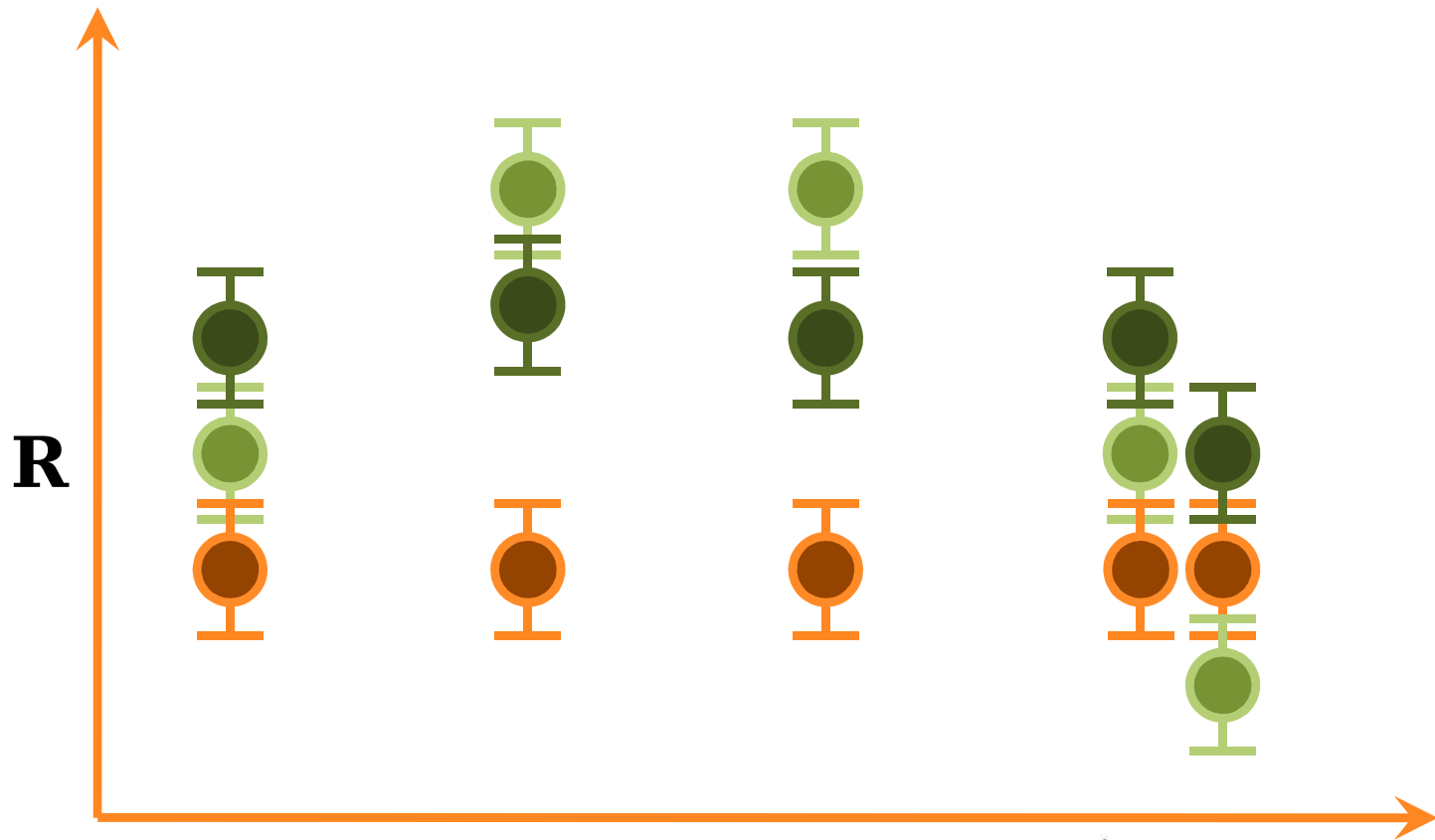
Smaller sample needed

Observed resistance level
is influenced by the
evaluation method

When comparing
resistance levels,
homogeneity of evaluation
method is critical.

Different evaluation
method uncover different
resistance mechanisms

Comparing two resistances



Bolero / Presto: Bolero always significantly more resistant.

Texto: Strong effect of the evaluation method.



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