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
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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**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

- **Spray inoculation**
- **Drop inoculation**

**Disease Severity evaluation**

**Real-Time PCR**

**Conidia germination**

**Symptom number**
Experiment setup

Non detached leaves
Incubation chambers: higher moisture

Pre-defined drop volume (5µL)
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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Four evaluation methods

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

Disease index

Days Post-Inoculation

Presto always shows stronger disease indexes than resistant cultivars.

Maximum difference observed at 15 dpi.

No observed strain-cultivar interaction.
Four evaluation methods

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

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

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

Germination rate ≃100%, ∀ tested cultivar

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

Example on Texto: 7 germ tubes
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.
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
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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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