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# Scoring for stem health reveals a by now unexplored major resistance locus against blackleg disease in rapeseed breeding.

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**Abstract** Management of blackleg disease mainly relies on fungicides, resistant varieties and cultural practices. Prolonged growing of rapeseed carrying the same resistance trait will select for pathotypes that are virulent on this trait and thus rapeseed breeding has to provide different resistance genetics to prevent adaptation of *Leptosphaeria maculans*. We screened genetically diverse breeding lines for stem health at springtime which is more significant to plant performance in the field compared to leaf infection and observed high variability in necrotic spots and canker formation. Subsequently, an association study with DNA-chip derived genotype data revealed one major locus on chromosome A01 that contains the previously mapped blackleg resistance locus Rlm12 (Raman et al., 2016; 2020) and was highly linked to stem health. Using this information, we selected putatively resistant and susceptible genotypes by molecular marker and proved *L. maculans* as causal pathogen in controlled greenhouse experiments. Furthermore, this resistance was challenged with different *L. maculans* pathotypes. Corresponding data are presented here and offer a new solution for sustainable blackleg management in rapeseed cropping.



## Methods and Results

### Scoring of stem symptoms in winter oilseed rape field nursery:

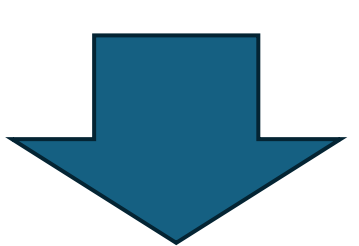
2000 breeding lines in the years 2022 and 2023



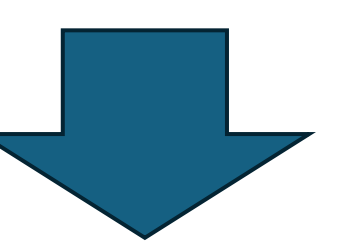
### Genotyping of plant lines with DNA-Chip and association analysis (GWAS)



### Molecular marker design and selection of independent breeding lines



### Validation of resistance associated locus in biotest with *Leptosphaeria maculans*



### Hybrids with superior stem health due to Rlm12 mediated resistance

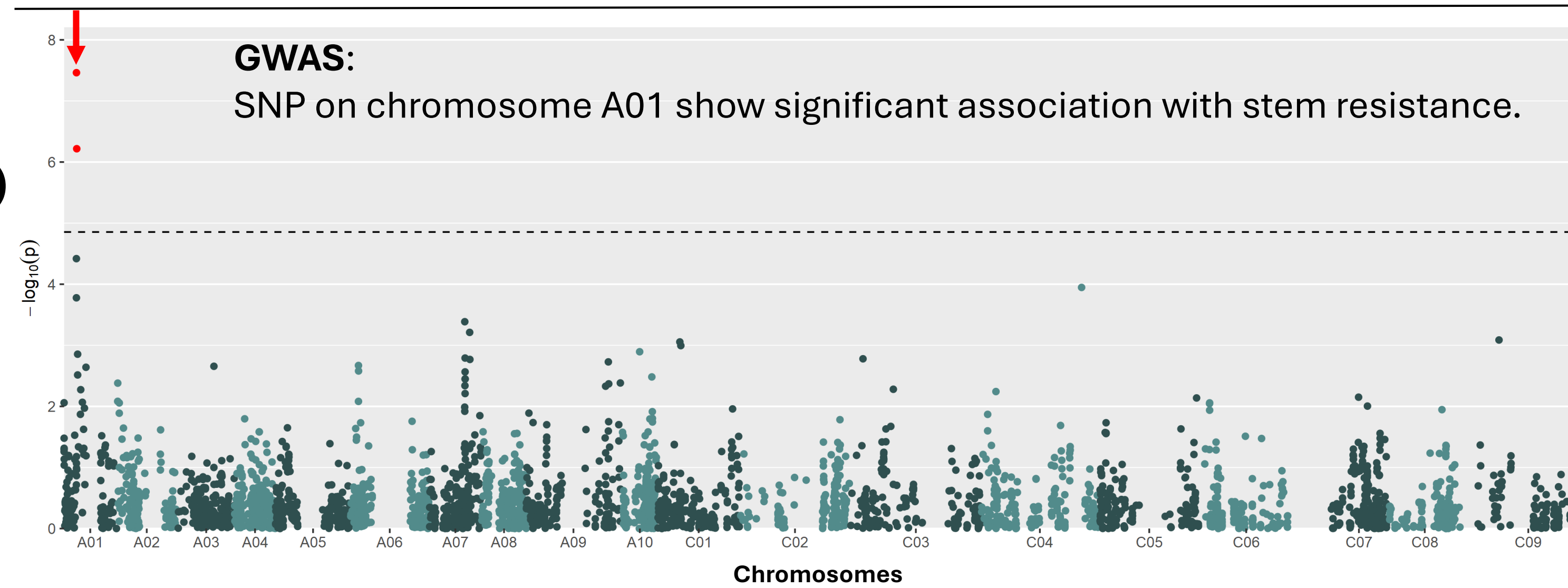
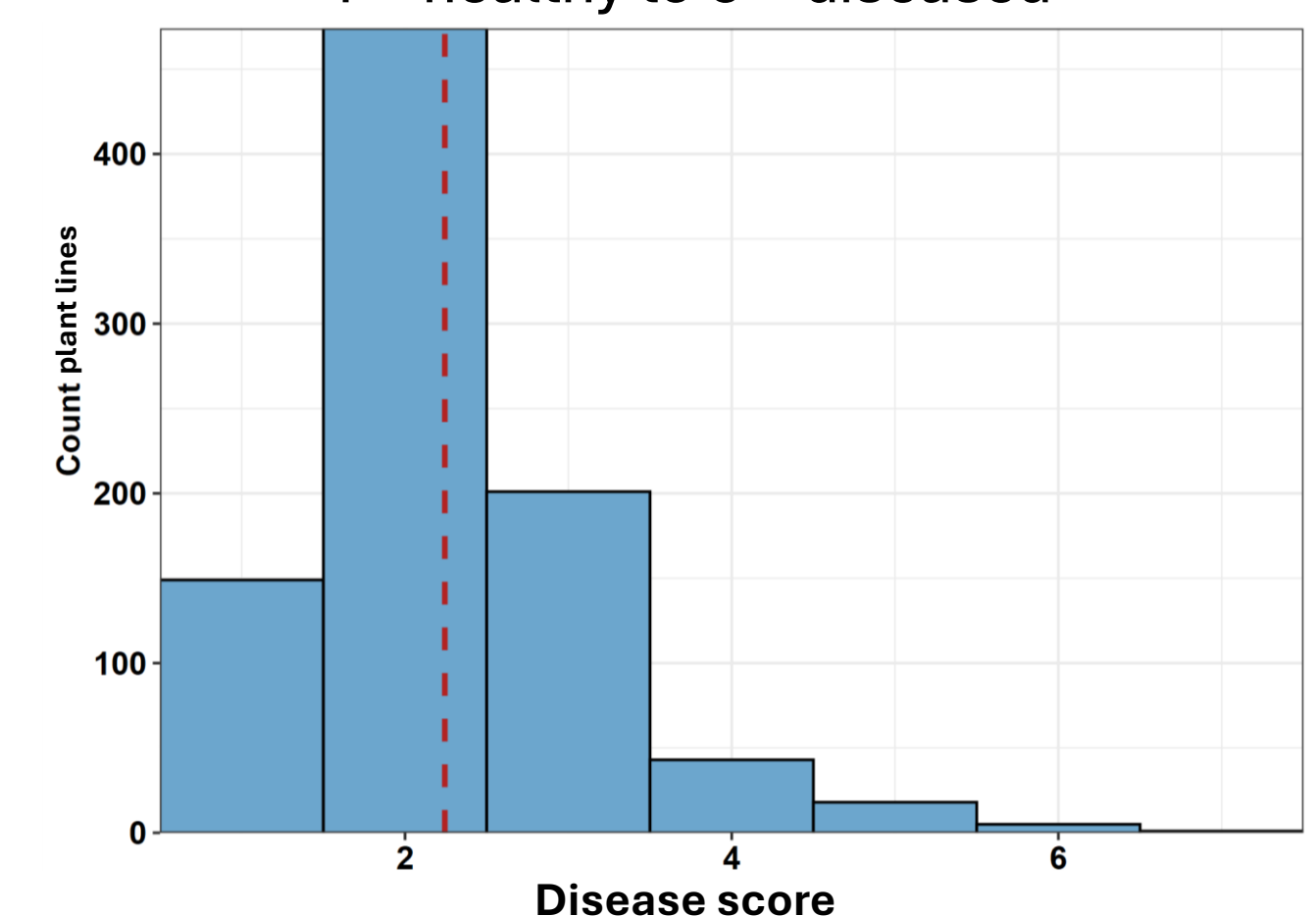
### Line observation in a field plot trial:

Differentiation in stem health. Insert: stem canker

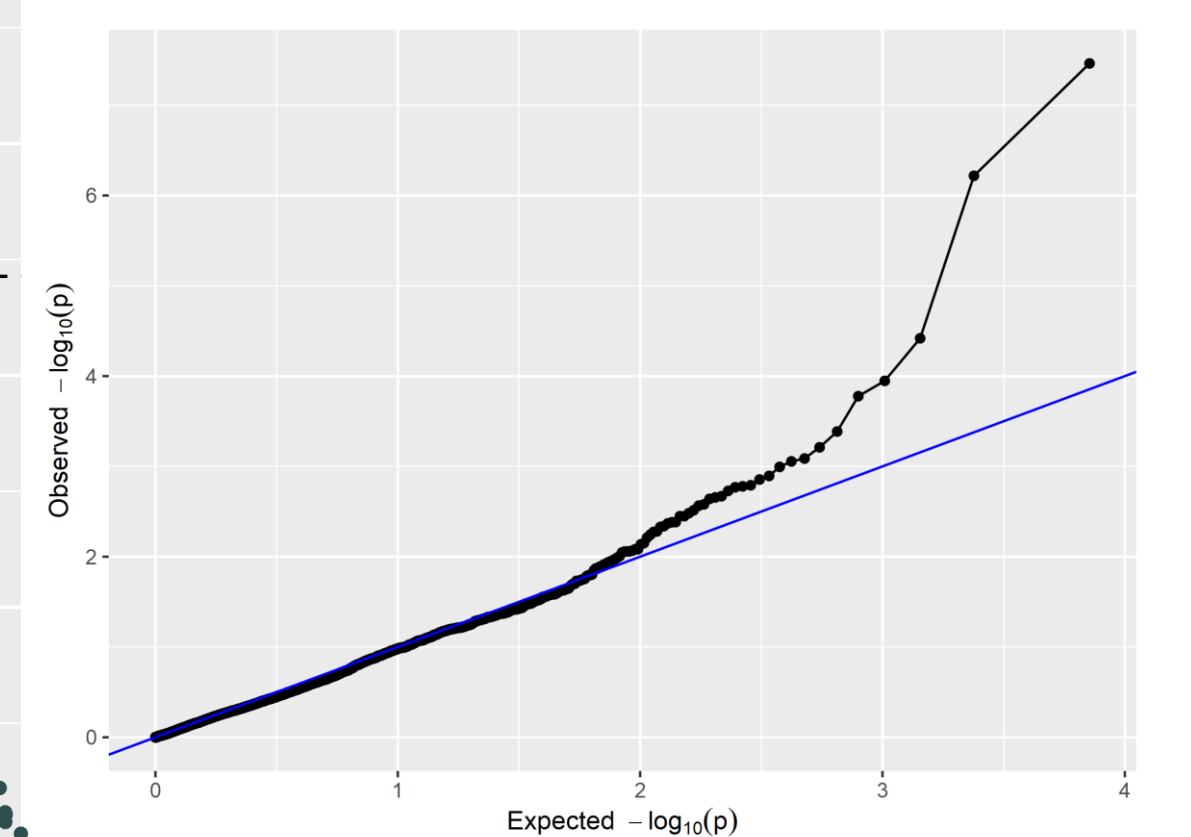


### Distribution of scoring values:

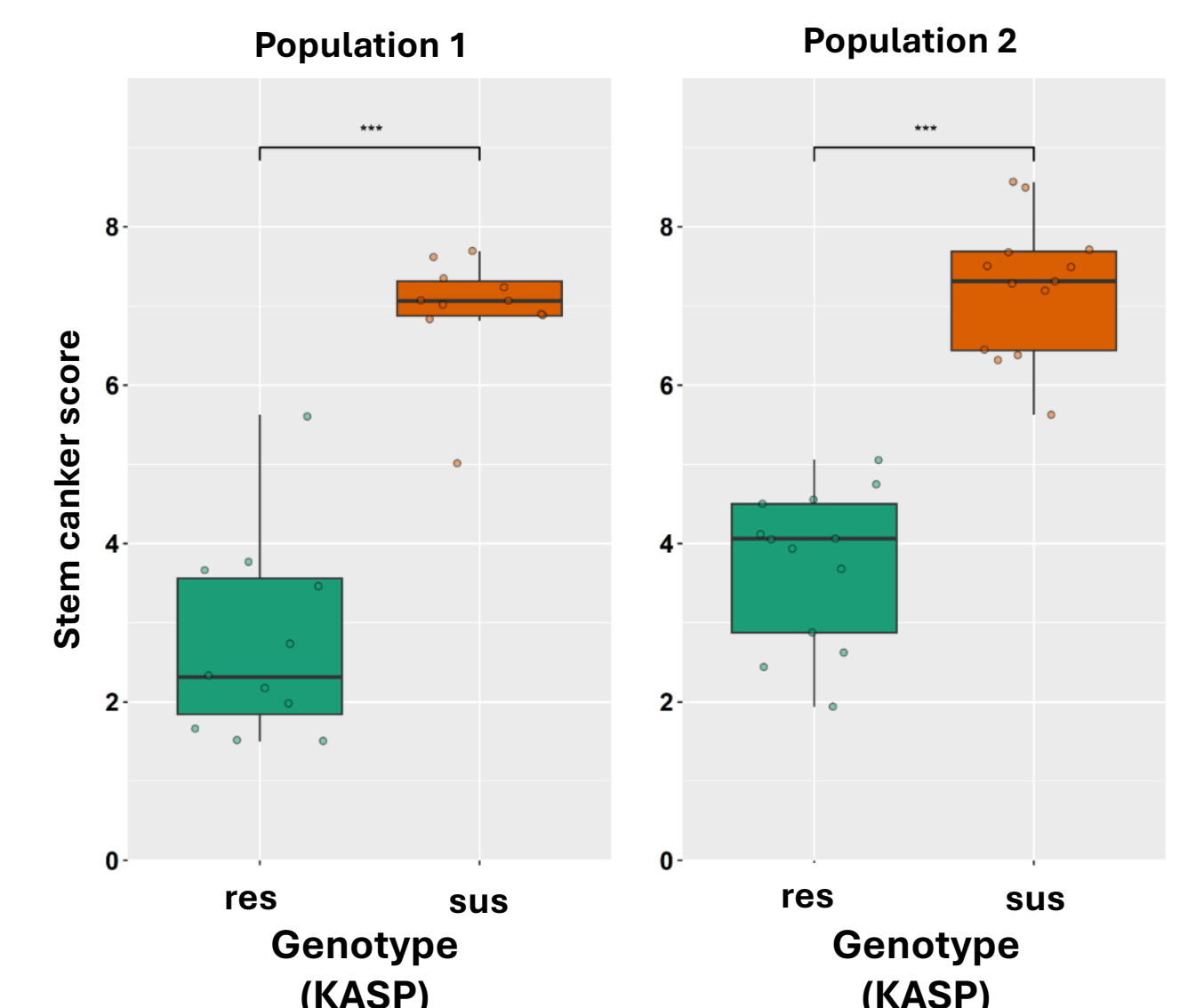
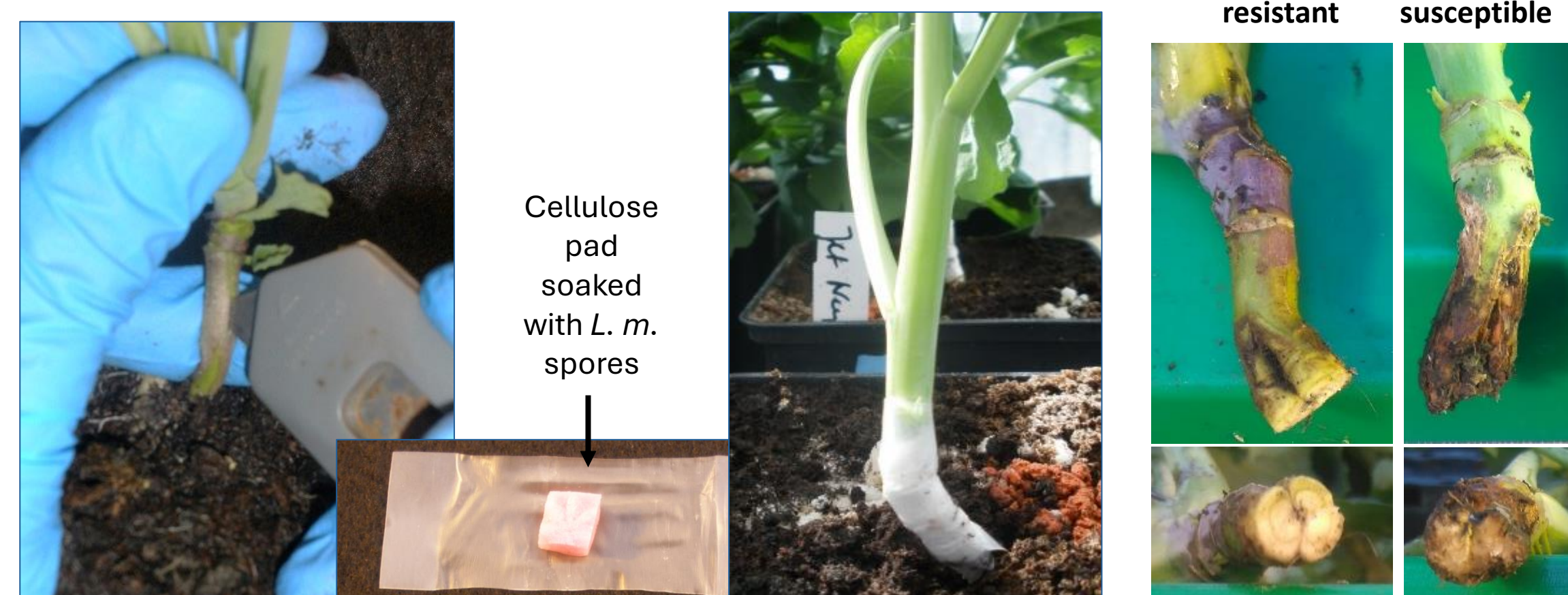
1 = healthy to 6 = diseased



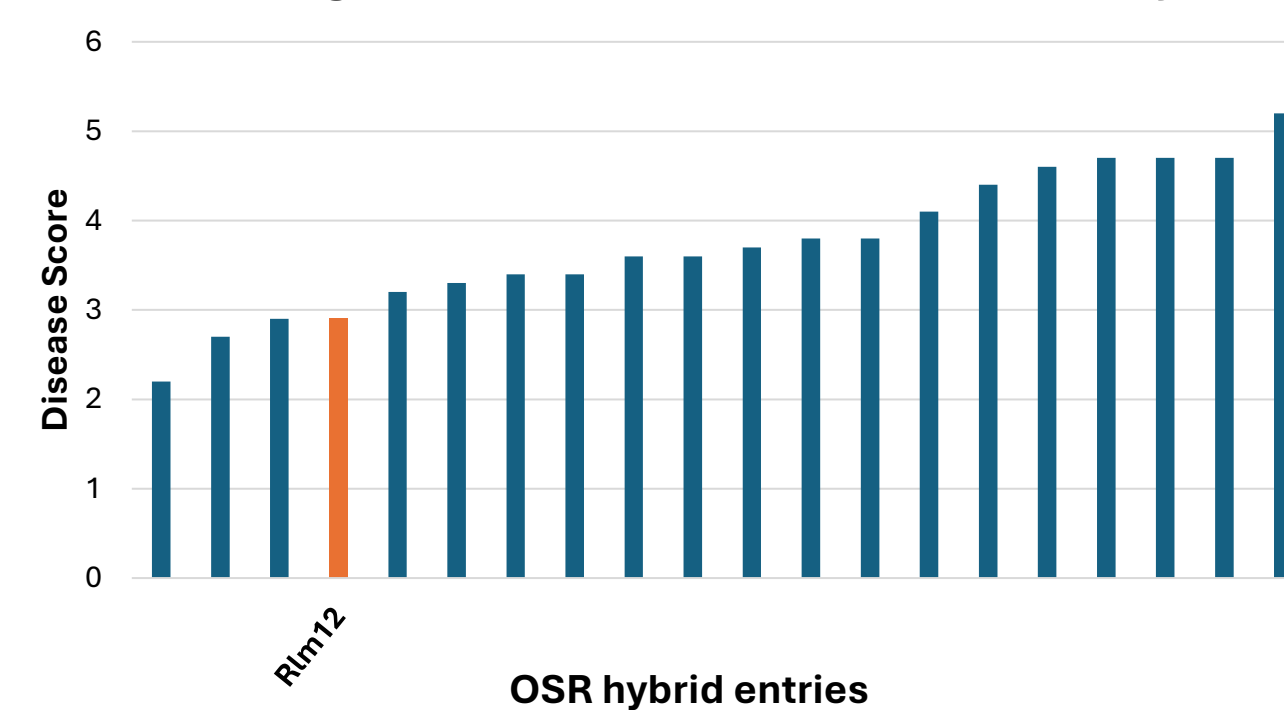
### Q-Q Plot



### Artificial stem infection with *Leptosphaeria maculans*

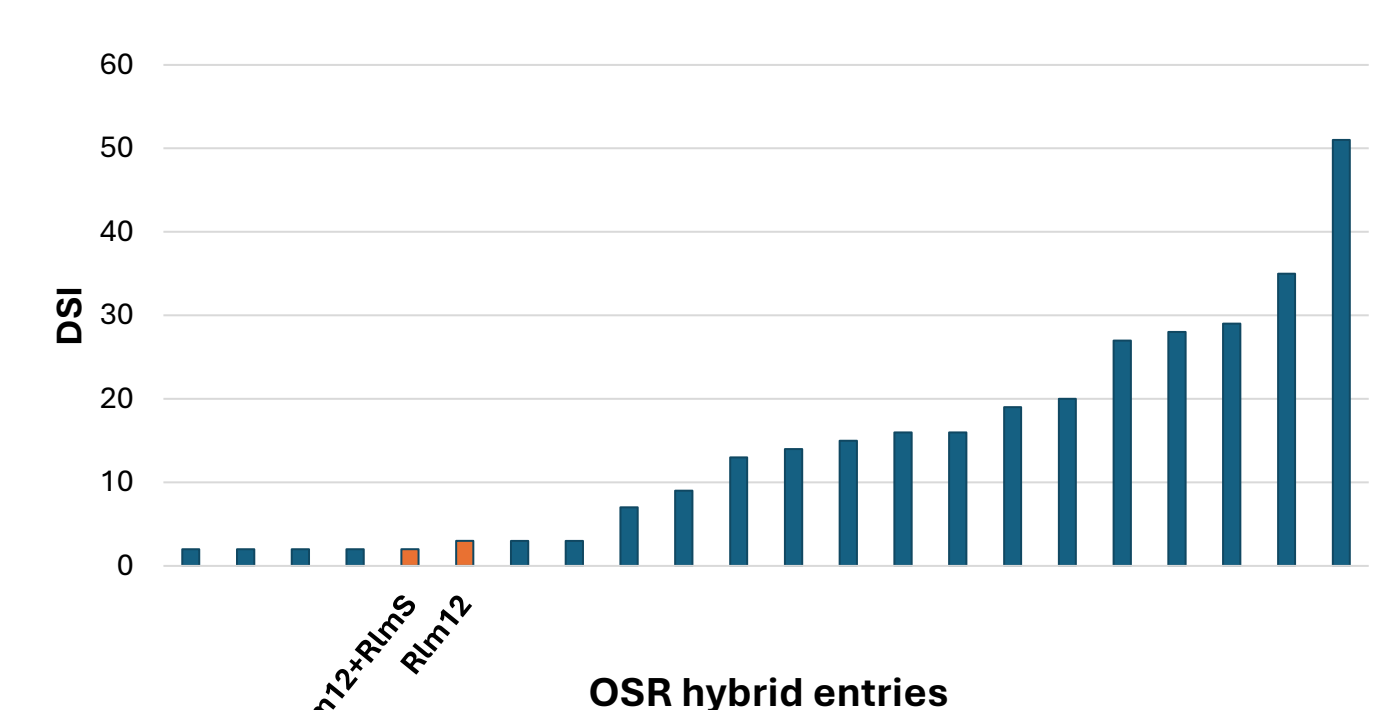


### Blackleg scores at official trials 2024, Germany



### Winter oilseed rape varieties with Rlm12 resistance in official trials

### DSI Stem canker at official trials 2024, UK



## Summary

- By means of disease score phenotypes from field nurseries and corresponding genotype data we found strong association between stem resistance and SNPs in one region of chromosome A01.
- The identified region includes the resistance locus Rlm12, previously described to confer resistance to stem canker (Raman et al., 2016, 2020).
- Biotests under controlled conditions proved high stem resistance to *Leptosphaeria maculans* of breeding lines carrying resistance-associated alleles.
- Oilseed rape hybrids with Rlm12 resistance stand out with low stem canker scores in official testing.

## Outlook

- For the first time, breeders employ Rlm12 mediated resistance to stem canker in oilseed rape hybrids and corresponding varieties of NPZ are in process for registration.
- OSR hybrids with Rlm12 supplement the existing portfolio of stem canker resistances and by this offer stable yield performance and higher flexibility in disease management.

## References:

- Raman H, Raman R, Coombes N, Song J, Diffey S, Kilian A, Lindbeck K, Barbulescu DM, Batley J, Edwards D, Salisbury PA and Marcroft S (2016) Genome-wide Association Study Identifies New Loci for Resistance to *Leptosphaeria maculans* in Canola. *Front. Plant Sci.* 7:1513. doi: 10.3389/fpls.2016.01513
- Raman H, McVittie B, Pirathiban R, Raman R, Zhang Y, Barbulescu DM, Qiu Y, Liu S and Cullis B (2020) Genome-Wide Association Mapping Identifies Novel Loci for Quantitative Resistance to Blackleg Disease in Canola. *Front. Plant Sci.* 11:1184. doi: 10.3389/fpls.2020.01184