

Using Phenomics and Genomics to unlock landrace and wild relative diversity for crop improvement



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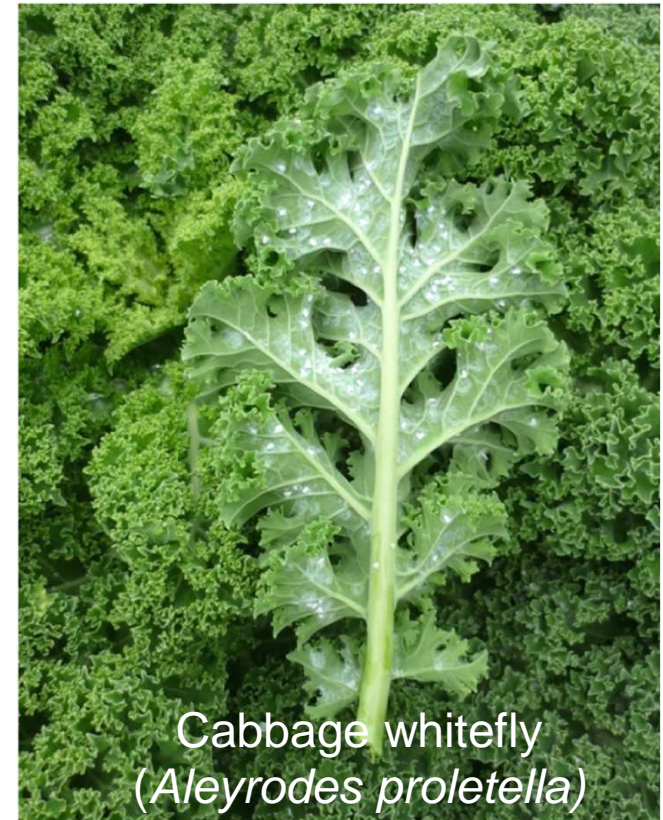
University of Nottingham

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The Insect Problem:

- Direct damage by
 - Phloem feeding
 - Secretion of honeydew
 - Sooty mold growth
- Reduced marketability of crop
- Problems increase
 - Ban on insecticides
 - Climate change

Host plant resistance



Aim of our work

- Finding host plant resistance to the cabbage whitefly and cabbage aphid via a germplasm screen
 - Crop wild relatives
 - Landraces
- Elucidating resistance mechanism
- Providing tools for breeding whitefly and aphid resistant varieties
 - Resistant plant material (donor)
 - Markers for introgression of QTLs

Germplasm screen

Field evaluations for resistance towards Cabbage aphid (UK) and whitefly (NL)



Germplasm screen for whitefly resistance

- Field experiment (432 accessions), Landraces, crop wild relatives
 - Non choice test, clip cages with 5 adult females, counting
 - Survival after 7 days
 - Number of eggs produced

- Confirmation in greenhouse



Result germplasm screen

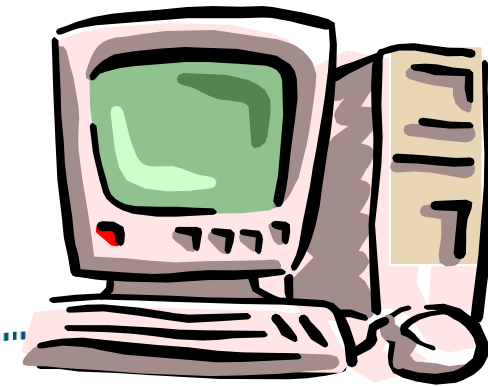
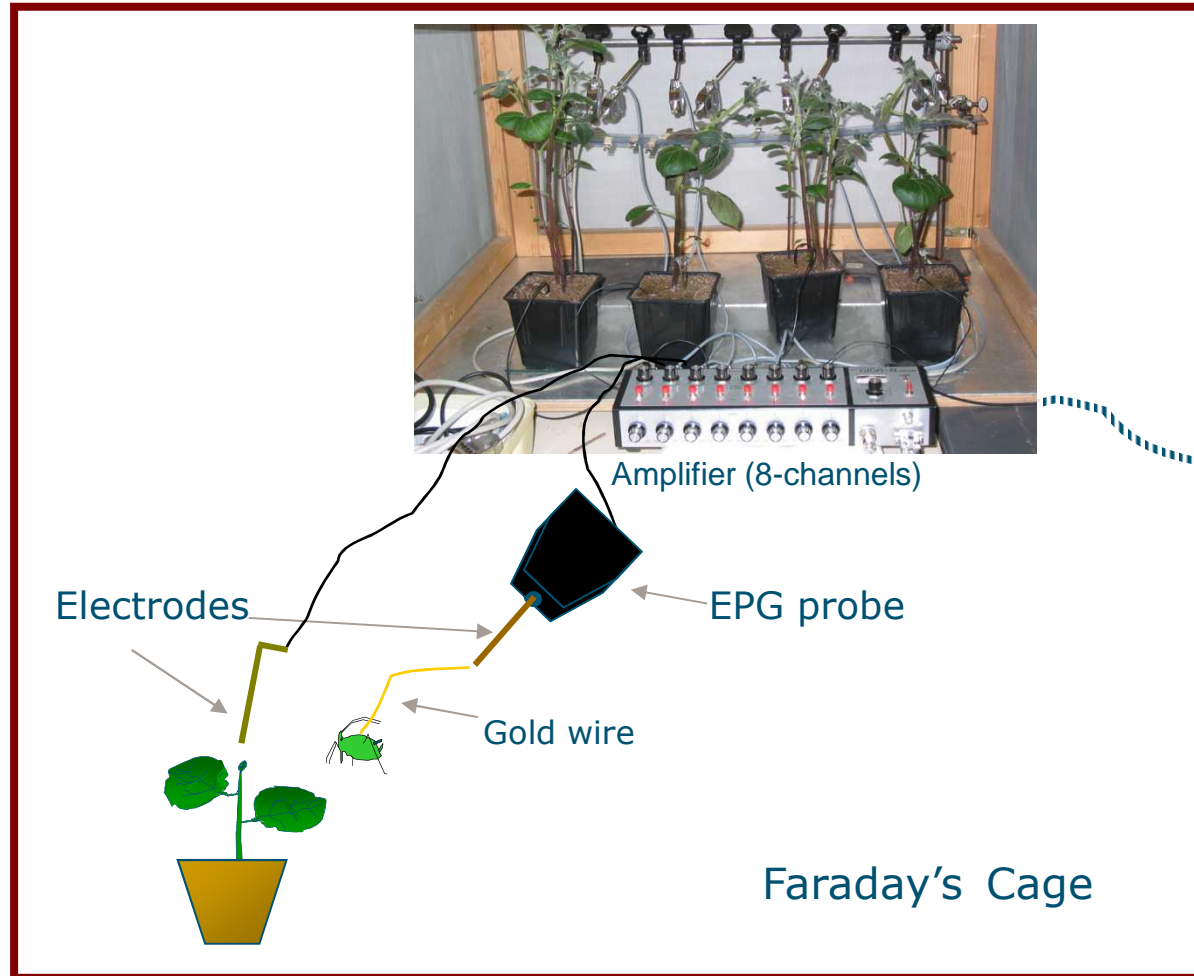
- Strong resistance in some landraces and varieties of heading cabbage (*B. oleracea* var. *capitata*)
- Strong resistance in some Crop Wild Relatives
 - *B. villosa*
 - *B. incana*
 - *B. montana*
- Characterization of resistance
- Mapping populations, QTLs
- Identification of genes involved



B. villosa

B. oleracea acephala

Electrical penetration graph (EPG)



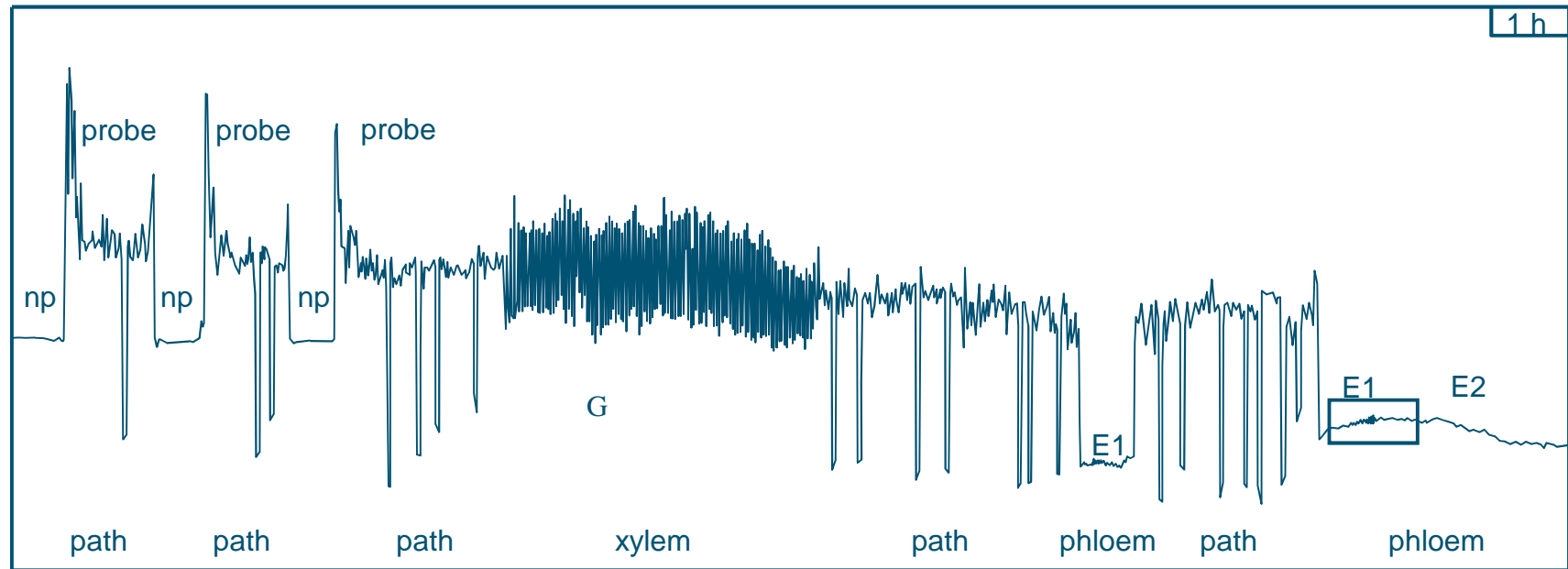
Data acquisition,
display and
recording of EPG
signals



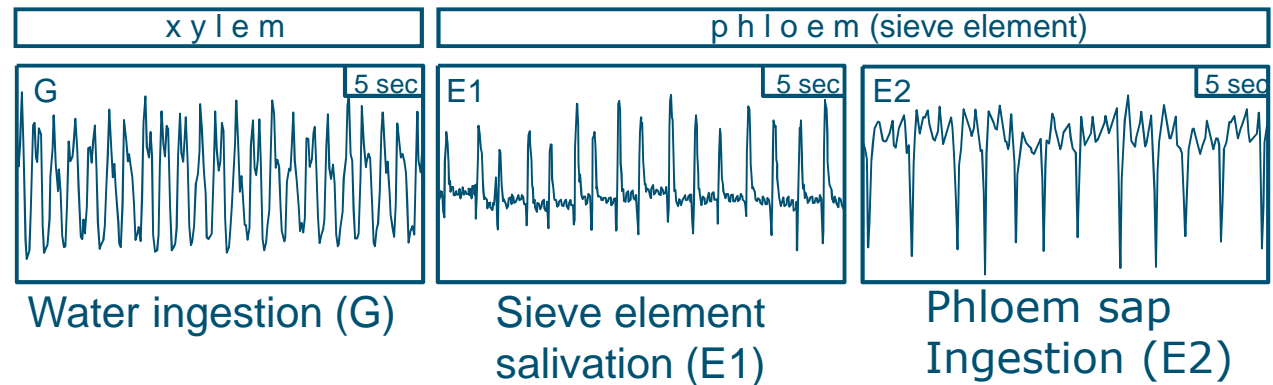
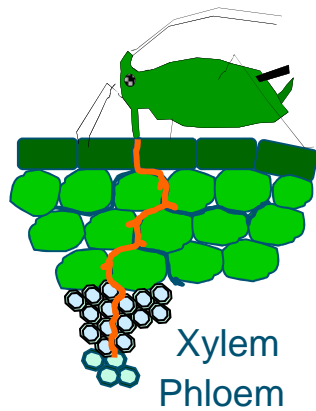
Data Analysis

Tjallingii, 1988

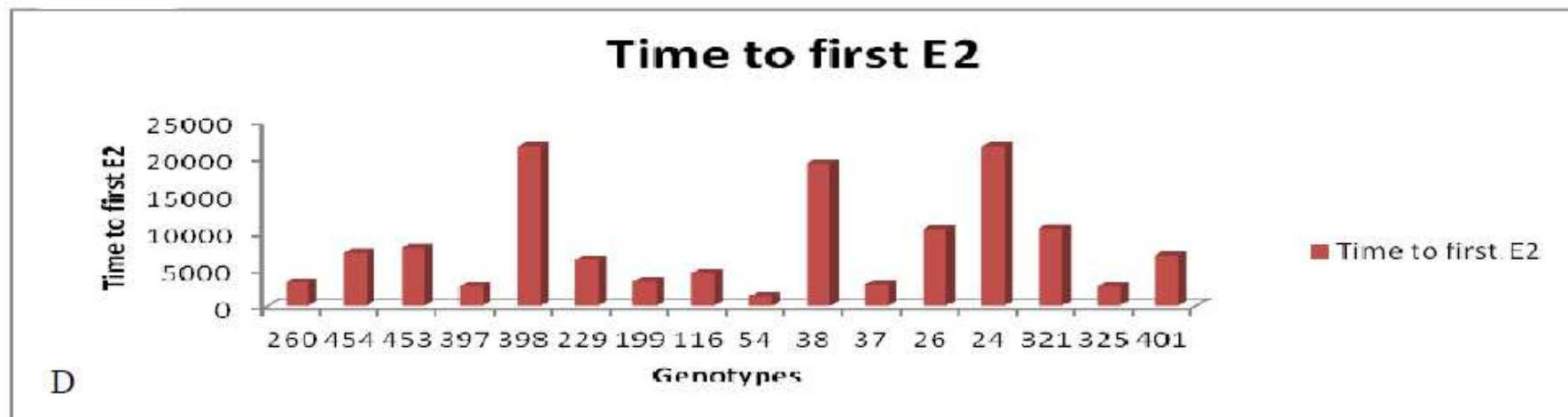
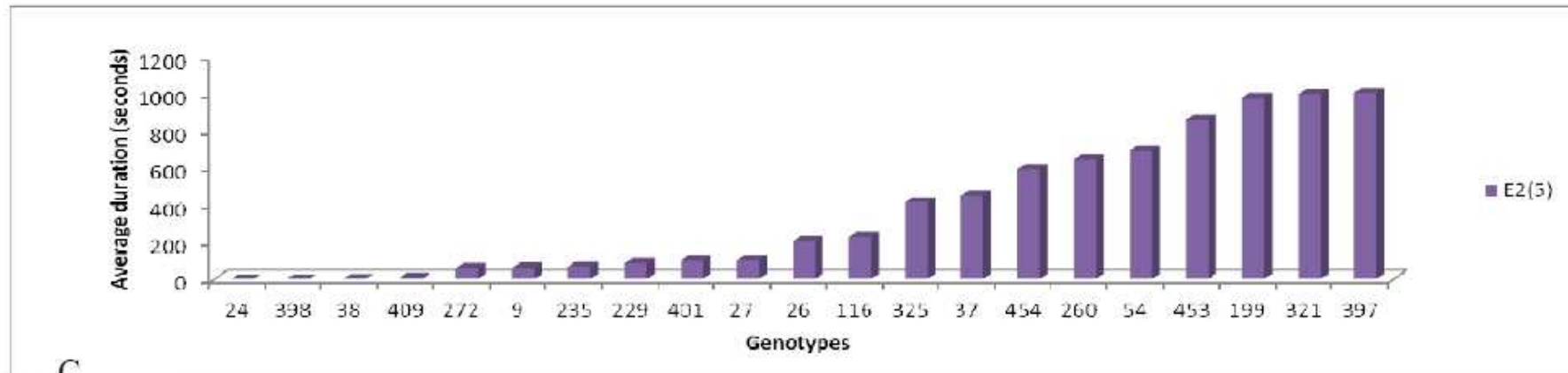
EPG waveforms and activities



DETAILS ACTIVITIES



EPG analysis with cabbage aphids



Characterization of resistance in white cabbage

White cabbage (*Brassica oleracea* var. *capitata*)



Rivera
F1 hybrid



Resistant

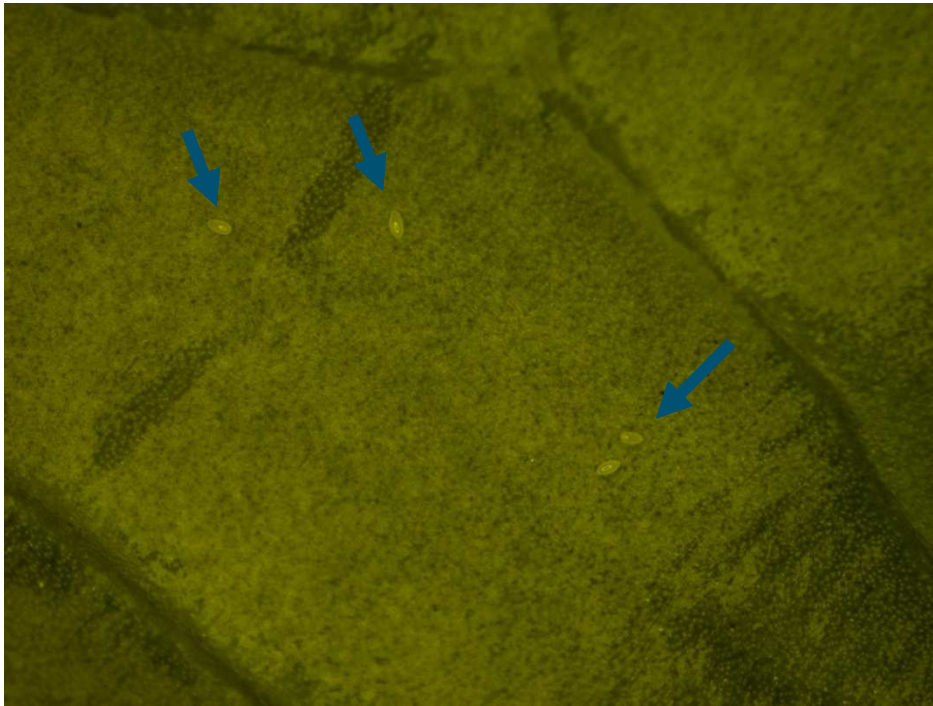
Christmas Drumhead
Open pollinated variety



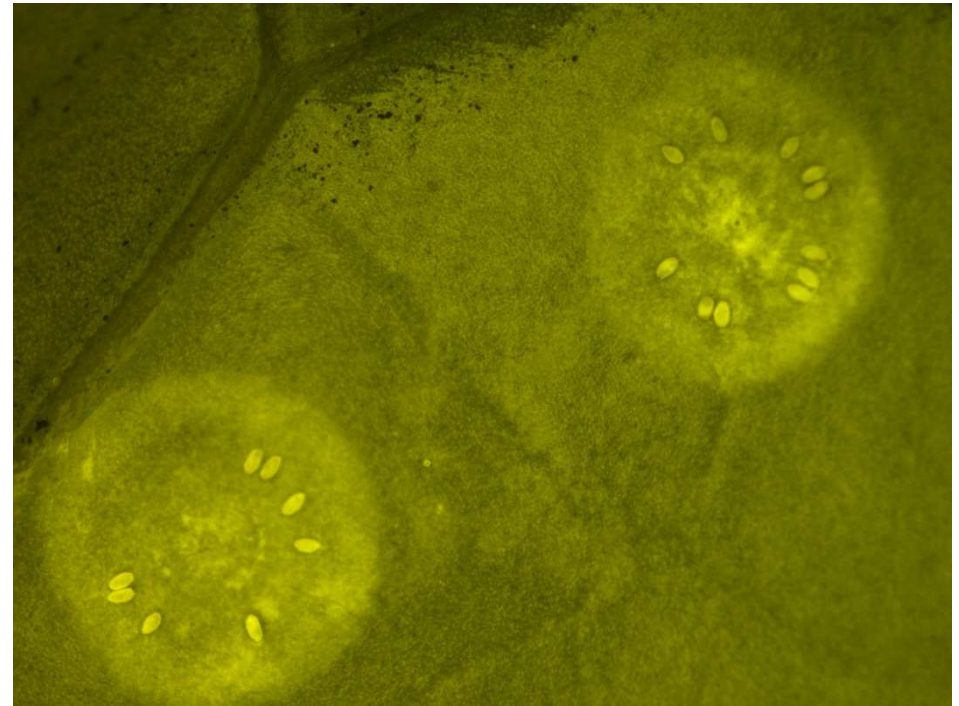
Susceptible

Oviposition behaviour

Rivera



Christmas Drumhead



Effect of plant age on whitefly performance



12-wk-old

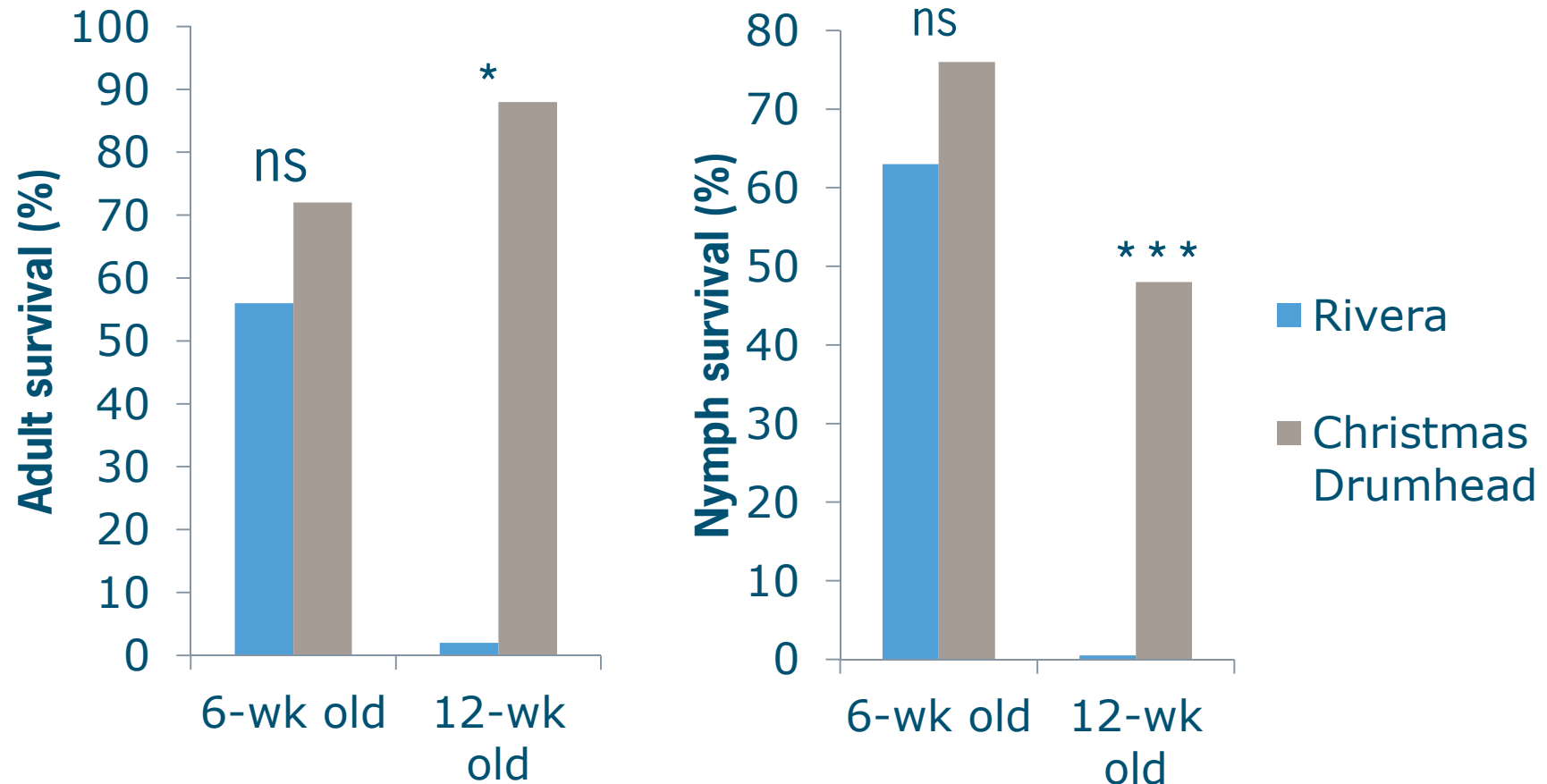
6-wk-old

- 2 plant ages
 - 6-wk old
 - 12-wk old

- No-choice test
 - Females in clip cages
 - Adult surv. after 1 wk
 - Nymph surv. after 3 wks

- Greenhouse experiment

Whitefly performance depends on plant age



Mapping populations for QTL analysis

Segregating populations:

- For cabbage whitefly resistance:
 - Christmas Drumhead (s) x Rivera (r)
 - *B. villosa* (r) x *B. oleracea* (s)
 - *B. incana* (r) x *B. oleracea* (s)

- For cabbage aphid resistance:
 - *B. fruticulosa* (r) x *B. fruticulosa* (s)



Brassica oleracea SNP-array

- Affymetrix Axiom 90K array
- SNP-selection:
 - 40,134 Broccoli
 - Equally spaced
 - 4,192 validated *B. oleracea* SNPs
 - 5,000 *B. montana*
 - 4,802 *B. fruticulosa*
 - 5,000 *B. incana*
 - 20,995 heading cabbage SNPs
 - 4,246 other *Brassica* spec. SNPs



Arrays will be shipped June 20th

Rivera x Christmas Drumhead population

- F2 population
 - 180 plants
- Phenotyping
 - Adult survival, oviposition rate (clip cages)
 - Developmental stage (head formation)
 - Leaf wax layer and toughness
- Genotyping
 - 150 SNPs (KASPar assay)
 - 15 per chromosome, n=9

Rivera x Christmas Drumhead population

trait	QTLs	Chr.	Position	LOD	% explained variance
adult survival	1	9	65.5	4.1	14.0
oviposition rate	1	4	51.6	3.7	12.7
wax layer	1	3	114.7	37.9	63.9
leaf toughness	2	3	100.1	4.5	11.4
		6	55.4	6.2	15.4
developmental stage	2	5	58.8	3.7	9.4
		2	17.8	3.4	7.9
dry weight	3	2	78.3	3.5	8.9
		4	31.0	3.8	8.9
		7	4.4	3.7	9.4

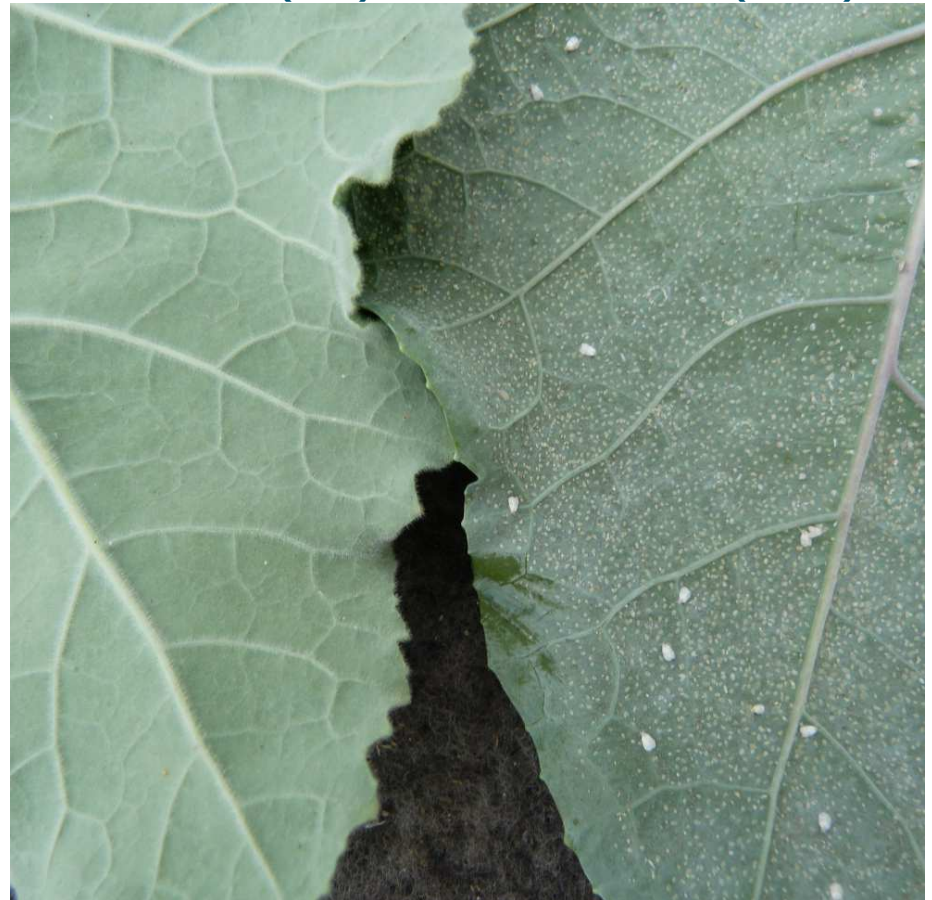
- None of morphological traits evaluated co-localized with whitefly adult survival and oviposition rate
- Whitefly resistance QTLs explain only small part of the variation
- More loci involved

Further information on poster by Koen Pelgrom et al.

B. incana x *B. oleracea* population

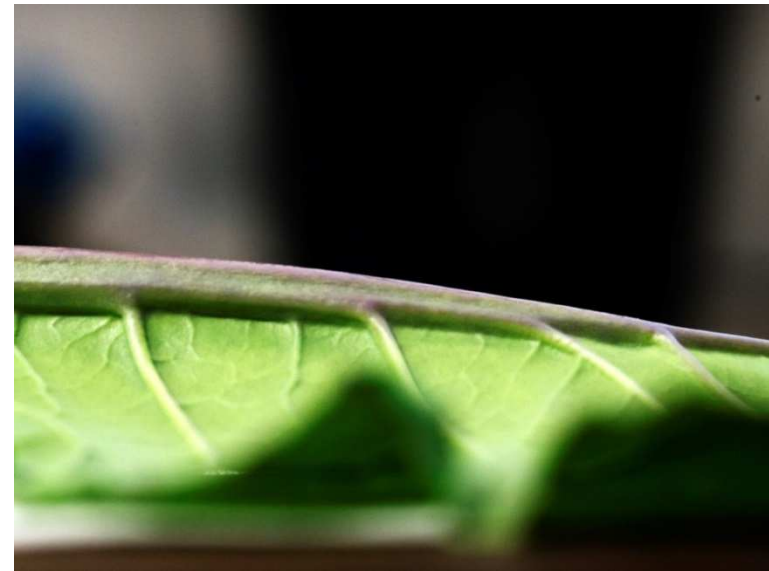
- BC1 population
 - 196 plants
- Phenotyping
 - Adult survival
 - Oviposition rate
 - Number of hairs
- Genotyping
 - 150 SNPs (KASPar)
 - 15 per chromosome

B. incana (24) x *B. oleracea* (111)



B. incana x *B. oleracea* population

- Strong correlation between trichomes and AS (-0.71) and OR (-0.89).
- No resistance without trichomes
- Genotyping on going, QTL mapping



Transcriptomics

- Assess the differences in gene expression in *Brassica* in response to aphids and whiteflies
- Three different experiments carried out
- Arabidopsis array used
- Will deliver information on gene networks and candidate genes for resistance

Further information on poster by Garima Sharma et al.



Conclusions

- Resistance to cabbage whitefly and cabbage aphid is present in *Brassica* spp.
- Whitefly resistance is found in several landrace accessions of *B. oleracea* var. *capitata* as well as in several CWR species
- The whitefly resistance identified in accessions of the CWR *B. villosa*, *B. incana* and *B. montana* is expressed both in six and twelve week old plants, which makes them novel sources of resistance for breeding
- The resistance mechanism differs among the sources of resistance
- *B. oleracea* 90k Axiom array available