

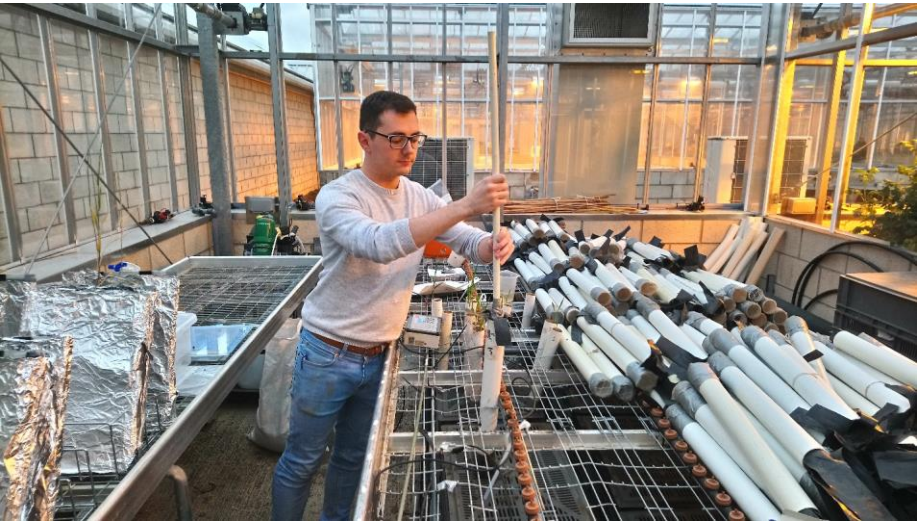
Managing herbivorous insects: the role decision support systems and resistant plant types

Dr Daniel Leybourne

@danielleybourne

Introduction

PhD on insect-plant interactions under drought stress (2015-2019. Dundee, UK)





Position at ADAS. working on the monitoring and management of herbivorous insects (2019+. York, UK)

Research Fellowship on herbivorous insect interactions across different landscapes (2021-2023. Hannover, Germany)



Overview: managing herbivorous insects

1) The role of decision support systems





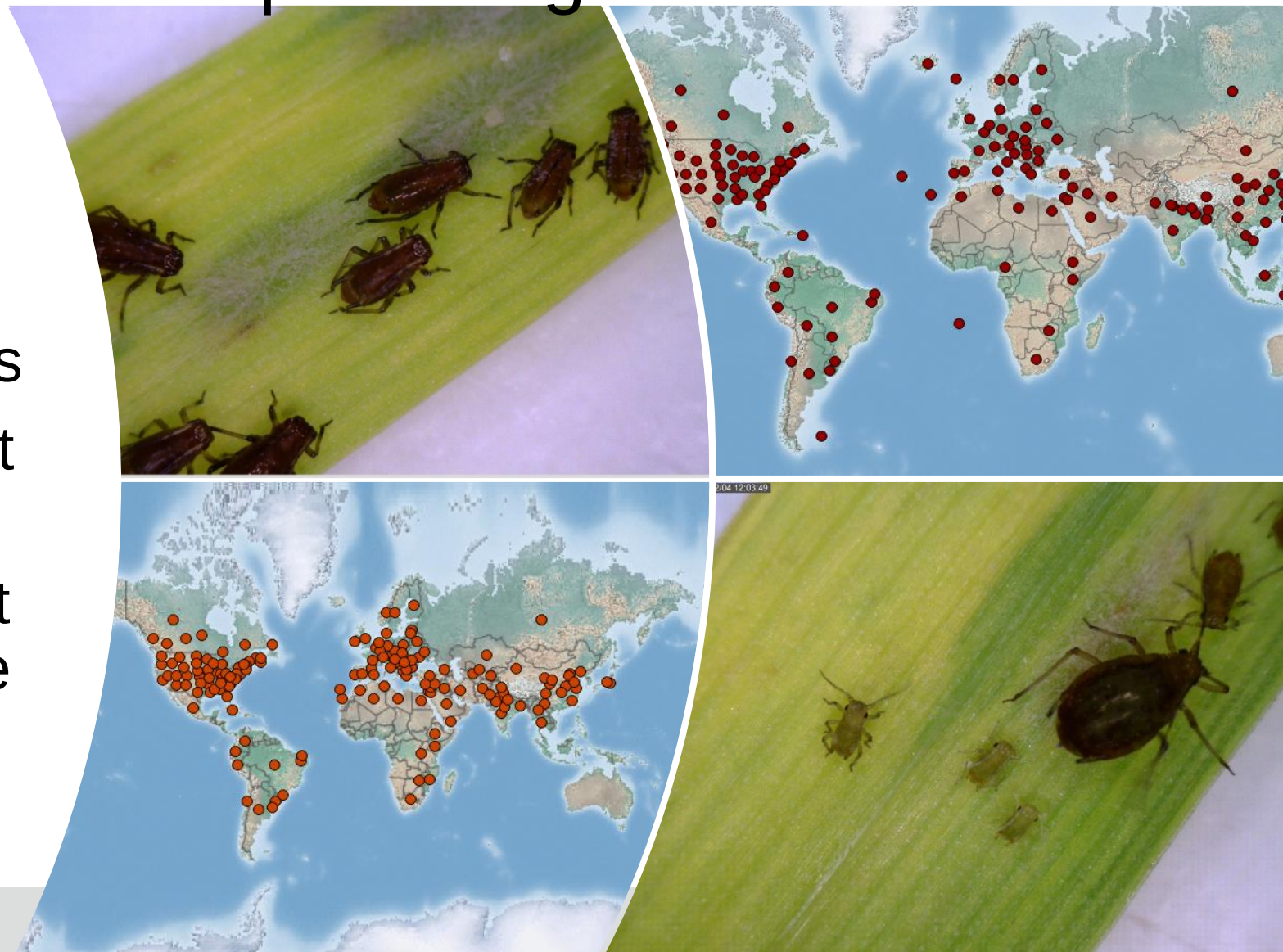
2) The role of resistant plant types





Cereal aphids: Important sap-feeding herbivorous insects

- Cereal aphids are globally significant
- Can cause significant yield losses in wheat, barley, oats
- Management options reliant on pesticide application
- Pesticide resistant / tolerant populations becoming more abundant



Wheat bulb fly

- Major pest of winter cereals along Eastern coast of the UK
- Larval stage of agricultural importance: stem-borers that cause “deadhearts”
- Chemical control limited to seed treatment
- Non-chemical control methods reported but not robustly tested
- Monitoring advised but involves soil sampling and manual egg extraction



Managing Herbivorous insects: the role of decision support systems

Pest detection



BYDV



Wheat bulb fly

What are decision support systems?

IPM Principles

1. *Prevention and suppression*
2. *Pest identification and monitoring*
3. *Decision based on monitoring and thresholds*
4. *Non-chemical methods*
5. Pesticide selection
6. *Reduced pesticide use*
7. Anti-resistance strategies
8. Evaluation

Pest detection

Correct identification important aspect of pest management

01

DETECT

- Rapid detection and quantification of wheat pest by mobile devices
- Integration of contextual information to improve accuracy and reliability of pest detection

02

INFORM

- Integration of pest numbers with economic thresholds to inform on risk
- Crop growth stage data used to highlight whether crop is in the risk stage for detected pest

03

ADVISE

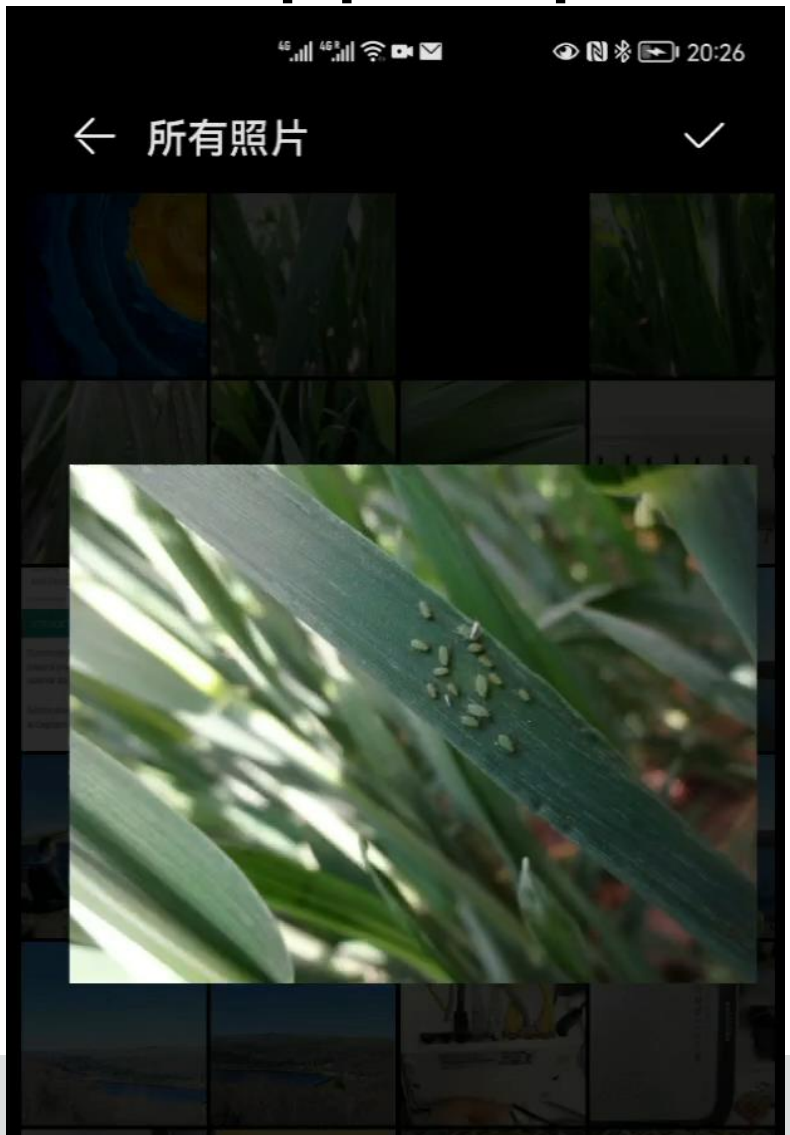
- Produce a risk output
- Estimate the potential efficacy of pesticide application (pest resistance status)
- Integration of contextual information to identify upcoming spray windows

Developing DSS to support pest identification

IPM Principles:

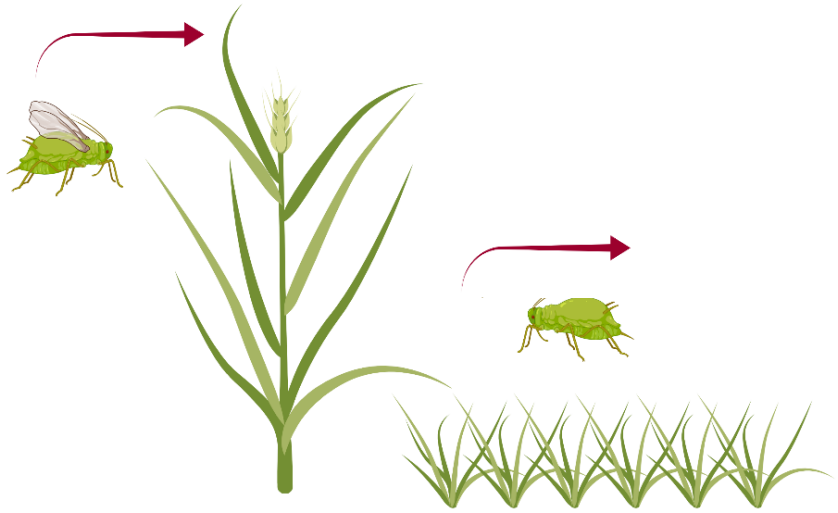
2. *Pest identification and monitoring*

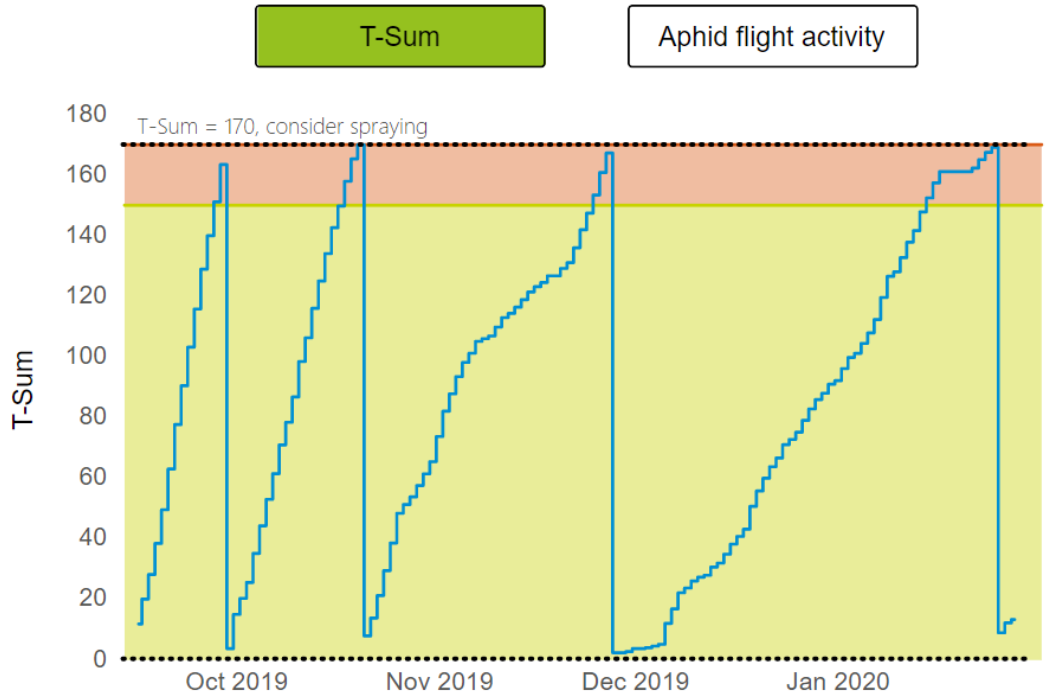
3. *Decision based on monitoring and thresholds*



Developing DSS for BYDV management







Not urgent: Spray threshold not met and/or not forecast to be met in next four days

Urgent: Spray threshold met. Check crop and consider treatment

Developing DSS for BYDV management

Aphid and weather data

Crop

% aphids with BYDV

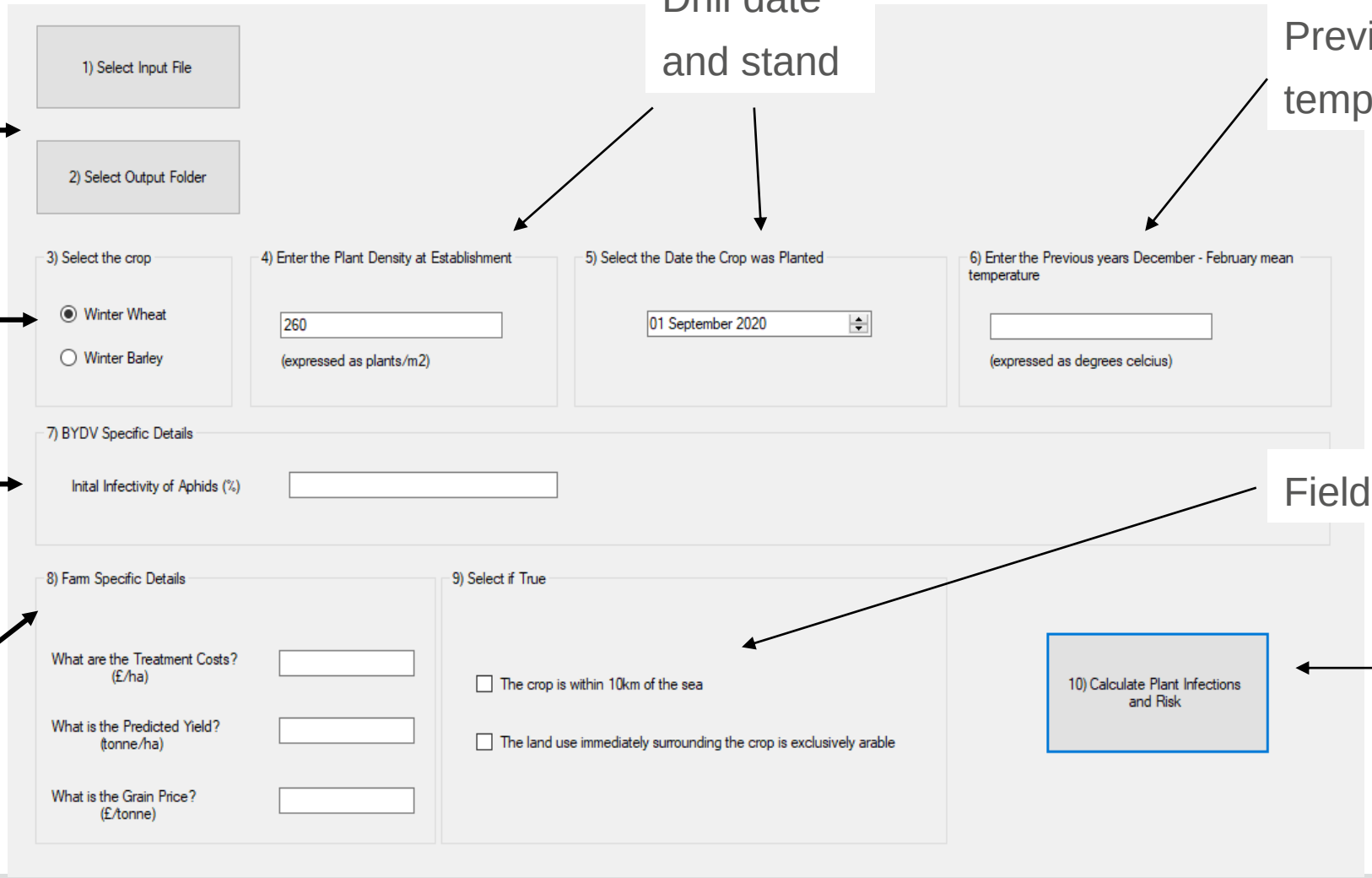
Crop agronomy

Drill date and stand

Previous winter temperature

Field location info

Click here to run the model



Developing DSS for wheat bulb fly management

<u>Challenge 1:</u> Can we better estimate seasonal wheat bulb fly risk?

Input:

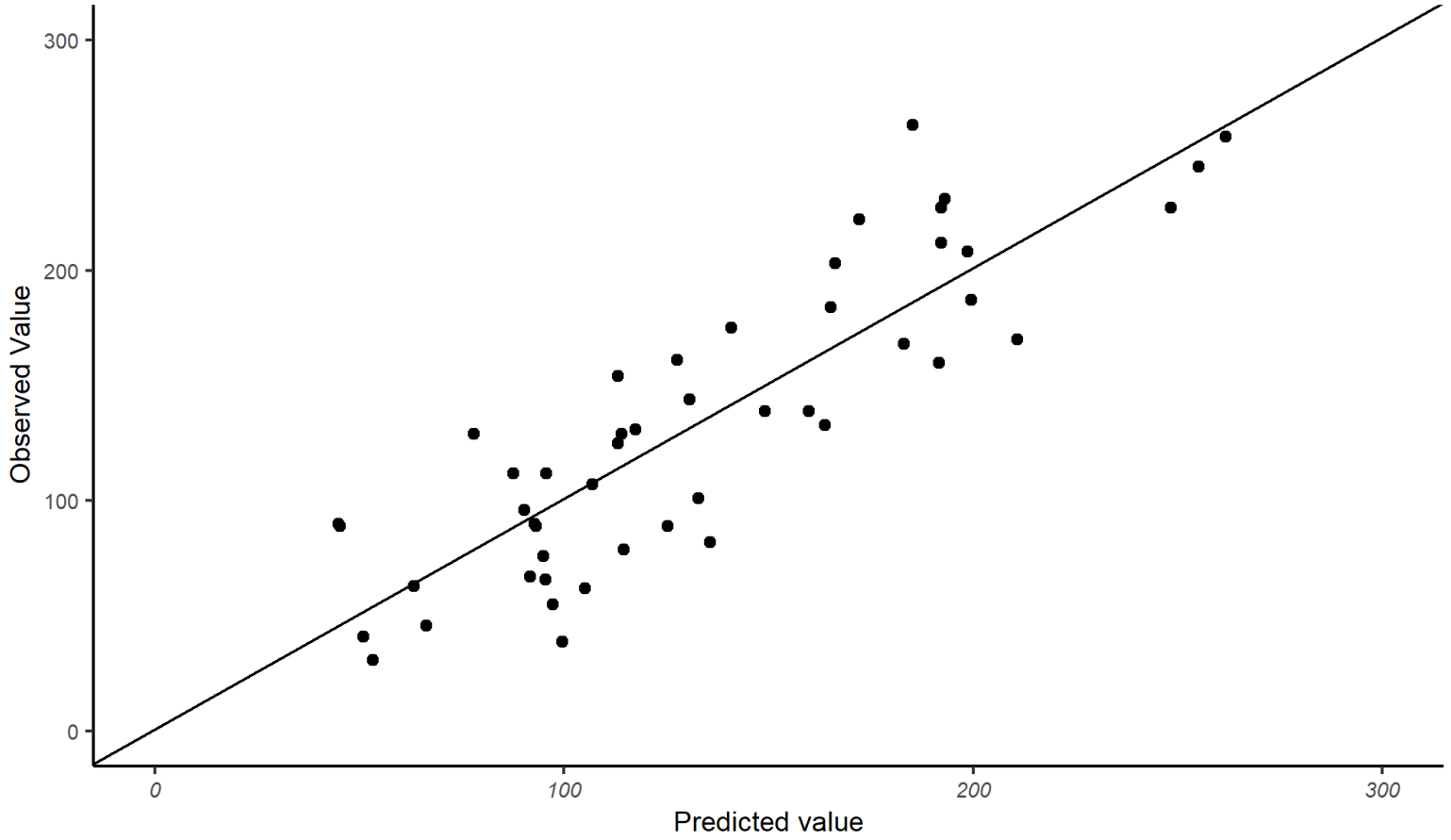
- Open-access meteorological data (departure from ten year long-term averages)

Sources of data:

- Meteorological office (departure from long-term average data)
- AHDB wheat bulb fly survey
  - 1952 – 1991: East Anglia
  - 2005 – 2019: East Anglia and Northern England



Developing DSS for wheat bulb fly management



- Model: adj-R^2 = 0.70

Region	Observed Average	Predicted Average	Deviation
North 2020	111 eggs m^2	107 eggs m^2	- 4 eggs m^2
East 2020	173 eggs m^2	60 eggs m^2	- 113 eggs m^2
North 2021	105 eggs m^2	62 eggs m^2	- 43 eggs m^2
East 2021	143 eggs m^2	157 eggs m^2	+ 14 eggs m^2

Developing DSS for wheat bulb fly management

Challenge 2: Can we predict crop tolerance to wheat bulb fly?

Input:

- Thermal time from plant emergence
- Leaf phyllochron length
- Target plant population (sowing rate)
- Sowing date (early, conventional, late)

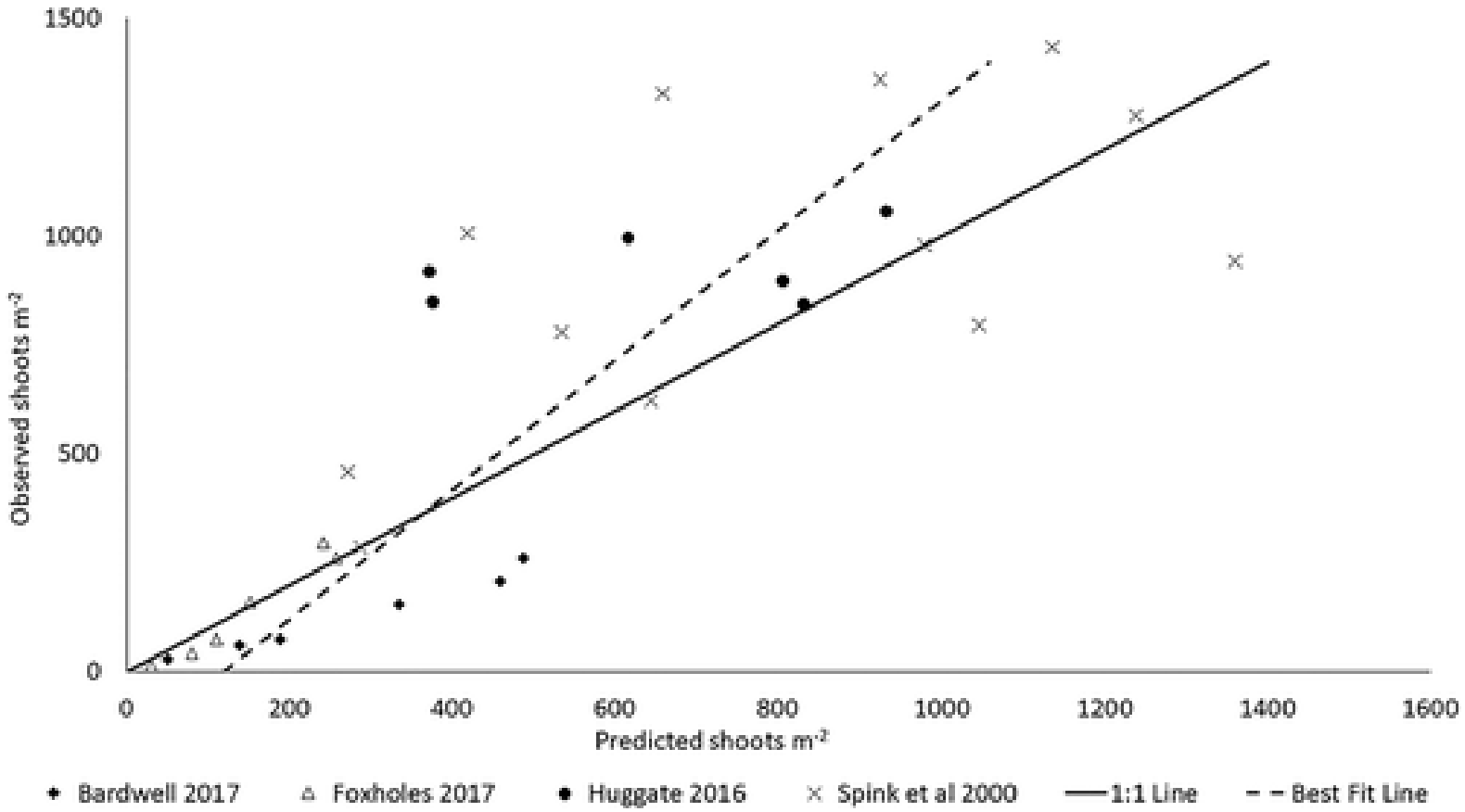
Sources of data:

- ADAS field trials
- Published studies

Wheat bulb fly egg count (eggs m^2)	Shoot numbers required to tolerate expected damage (shoots m^2)
125	720
250	940
500	1380
750	1820

Leybourne, Storer *et al.*, 2022, *Annal. App. Bio*

Developing DSS for wheat bulb fly management



- Model: adj-R^2 = 0.65

Developing DSS for wheat bulb fly management

1) Use the pest level prediction model to estimate seasonal pest levels 

2) Use pest tolerance levels to estimate the number of shoots required to tolerate pest damage

Delia coarcata eggs (m^{-2})	Minimum shoot number needed to tolerate damage (m^{-2})
125	720
250	940
500	1380
750	1820

3) Use the shoot number prediction model to predict the maximum number of shoots a crop will produce using the planned sowing date and seed rate 

4) Subtract the minimum number of shoots needed to tolerate the predicted level of pest pressure from the predicted maximum shoot number

5) If the result is positive, there is a high chance that the pest can be tolerated naturally. If the result is negative, consider one of the following IPM strategies

A) Adjust the planned sowing date or/and seed rate to achieve the minimum shoot number needed to tolerate damage 

B) If the crop cannot be sown before November then consider using an insecticide seed treatment 

C) Change rotation and grow an alternative crop 

IPM Principles:

2. *Pest identification and monitoring*

3. *Decision based on monitoring and thresholds*

4. *Non-chemical methods*

Leybourne, Storer *et al.*, 2022, *Annal. App. Bio*

Managing Herbivorous insects: the role of decision support systems





Pest detection:

- Works well for insect detection
- Will include context information to enhance identification
- Will include context information to support management

BYDV:

- System incorporates more agronomic factors
- Aims to reduce pesticide use and target when needed
- Testing and validation ongoing

Wheat bulb fly:

- Annual population prediction model developed
- Shoot number production model developed
- Combining models to create DSS
- DSS needs further testing and validation

Overview: managing herbivorous insects

1) The role of decision support systems

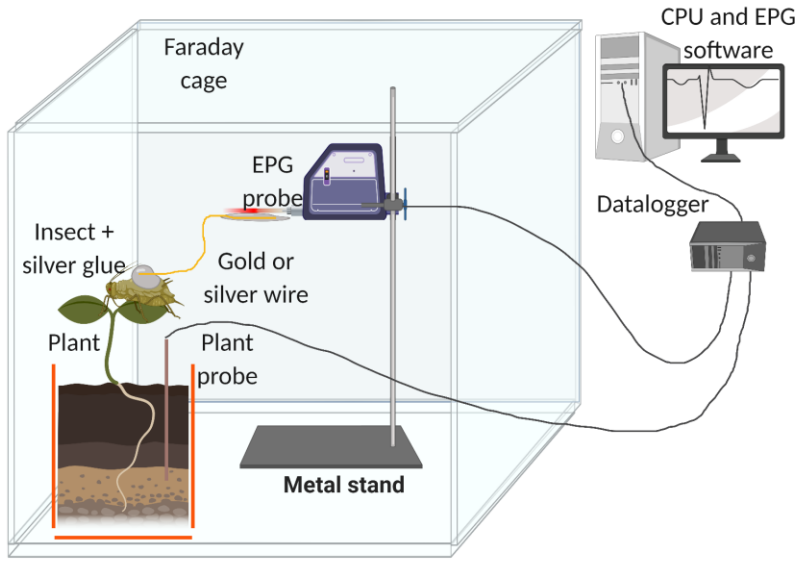
2) The role of resistant plant types



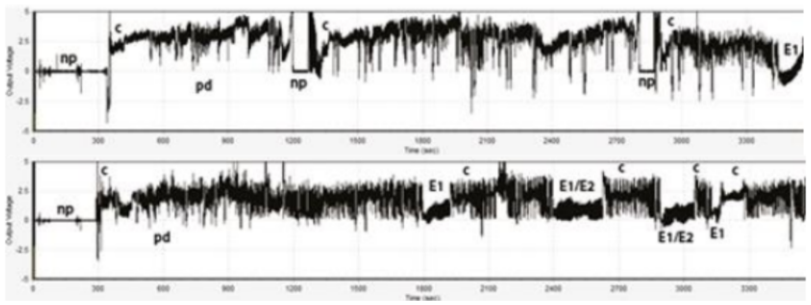


Identifying aphid resistance traits

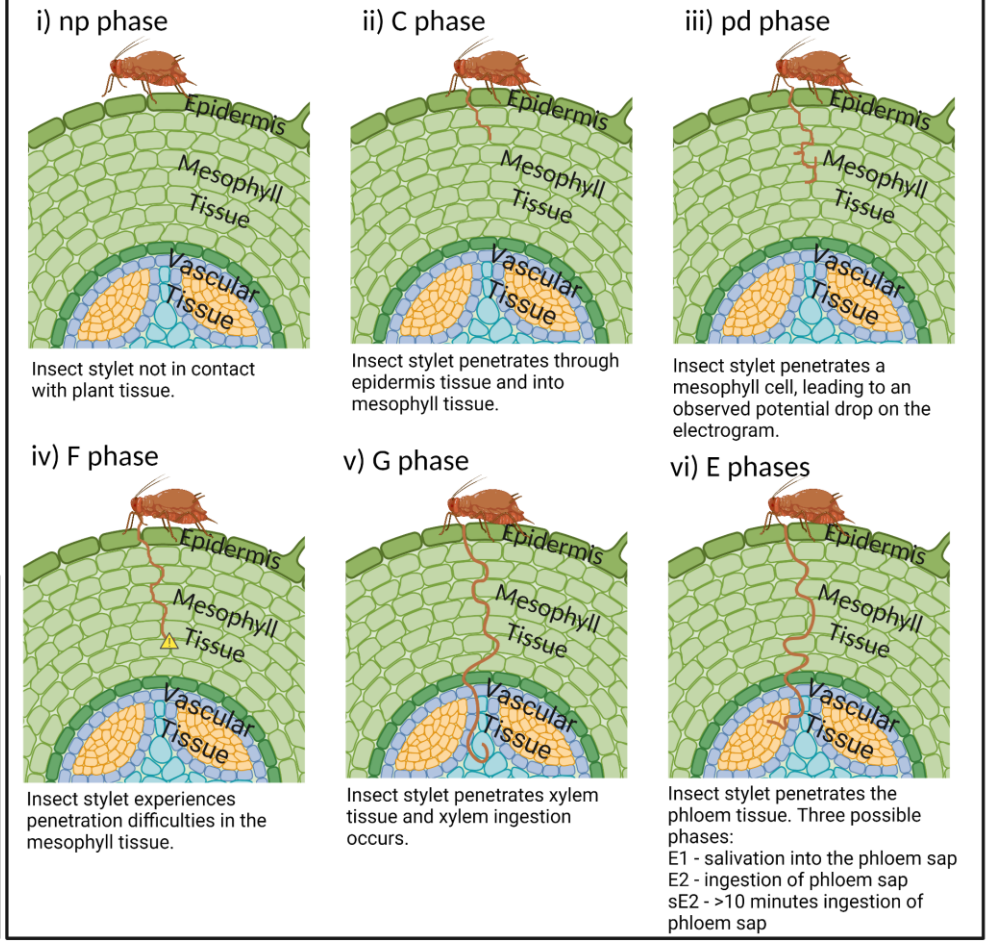
A) Graphical representation of the EPG experimental setup



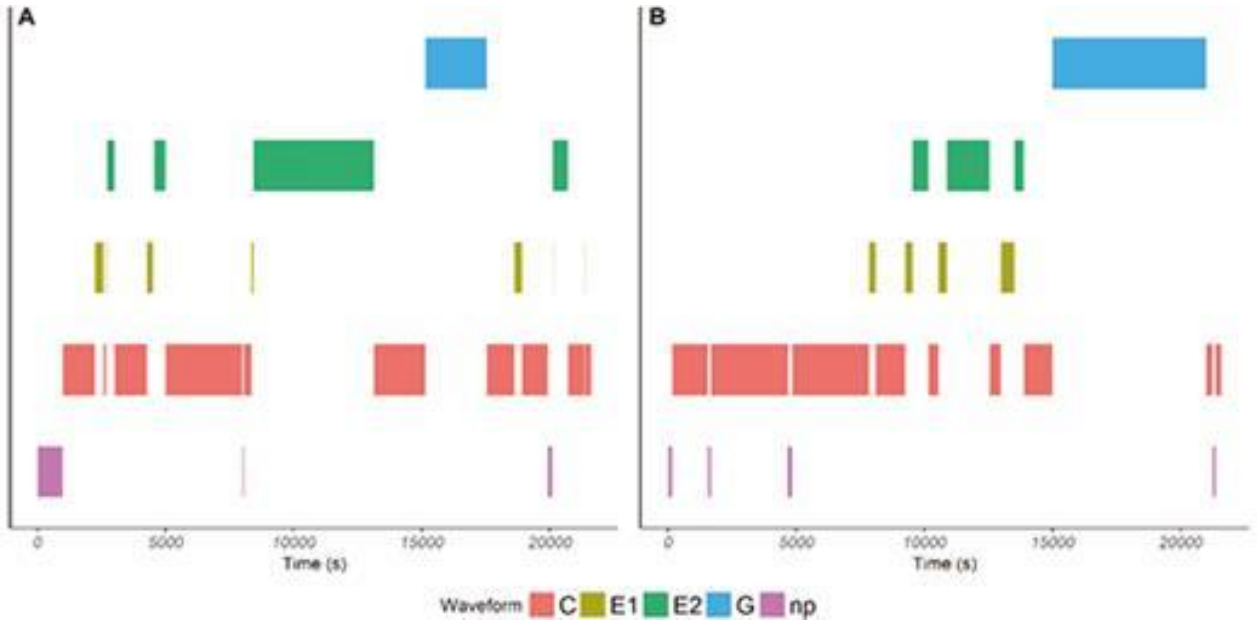
C) Example of EPG waveforms from a feeding study

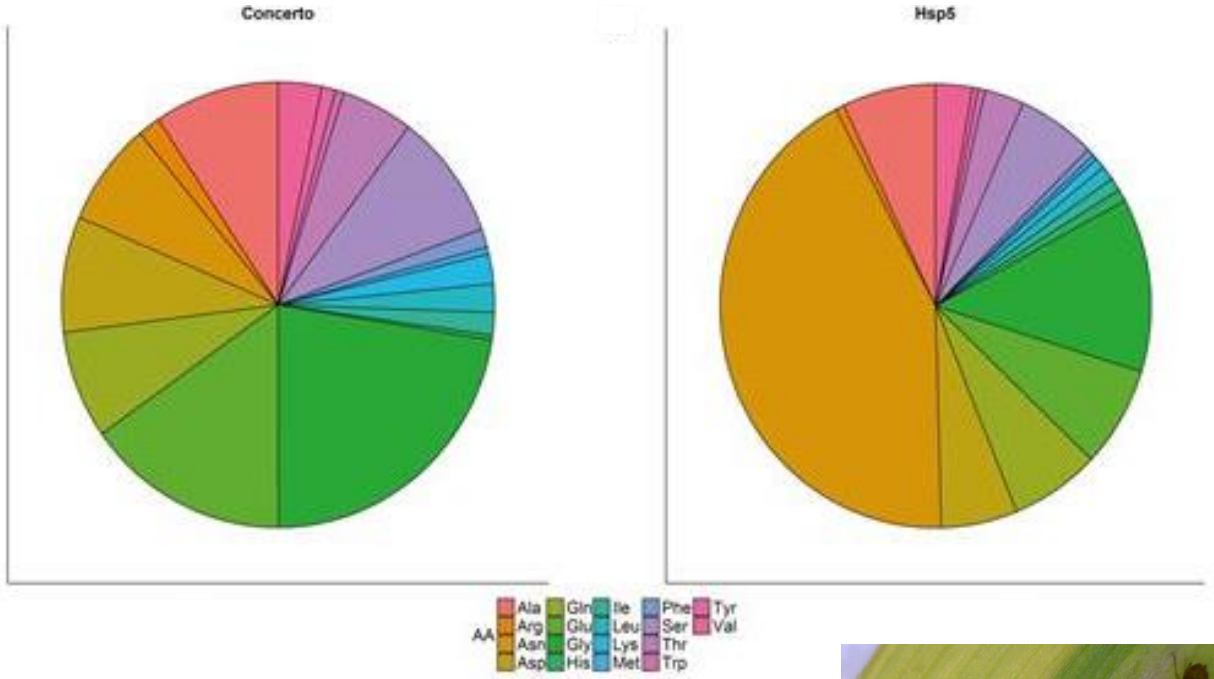


B) Overview of the main EPG phases and corresponding stylet activity in plant tissue



Aphid resistance mechanisms in wild barley



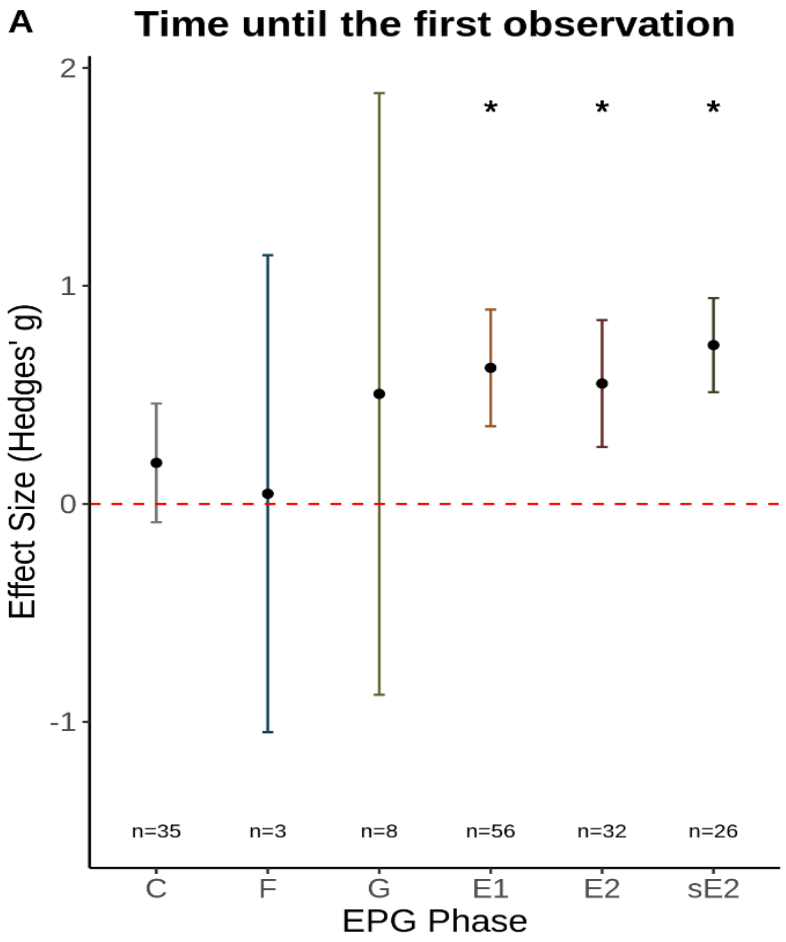


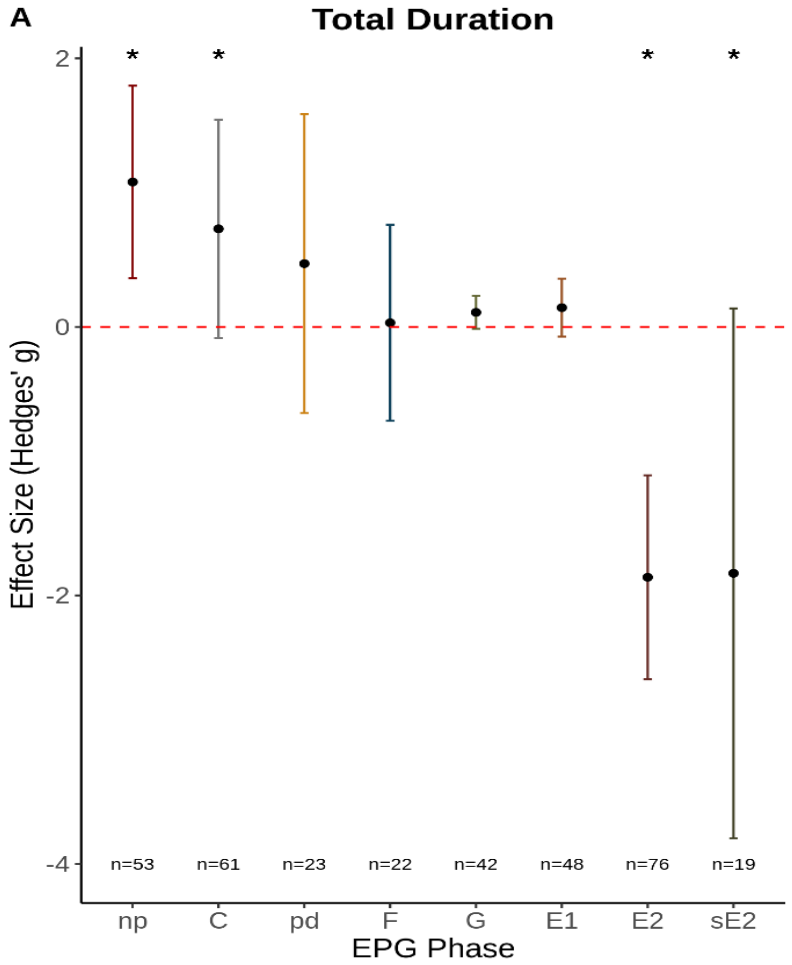


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Common resistance mechanisms







Leybourne & Aradottir, *Under Review, Sci Rep*

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Managing Herbivorous insects: the role of resistant plant types

- Resistance to cereal aphids in wild barley involves defence traits at phloem and mesophyll
- Resistance in wild barley involves altered biochemistry and thionins
- Meta-analysis identified similarities in reported defence mechanisms in wide range of pest-plant systems



Acknowledgements

Collaborators & project partners:

Dr Emily Martin (LUH: Fellowship host, cereal aphid pesticide tolerance)

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Dr Alison Karley (JHI: Plant resistance)

Dr Jorunn Bos (UoD: Plant resistance)

Dr Tracy Valentine (JHI: Plant resistance)

leybourne@geobotanik.uni-hannover.de
Daniel.Leybourne@adas.co.uk
@danielleybourne

