



## One Crop Health: Re-imagining next generation crop protection

# Prof. Paul Neve, Department of Plant & Environmental Sciences, University of Copenhagen

#### A brief introduction

#### A (grass) weed guy: ecology & evolution of weeds, herbicide resistance, integrated weed management.

- PhD, University of Liverpool, UK: Rare arable weeds.
- Postdoc, University of Western Australia: Herbicide resistance.
- Lecturer, University of Warwick, UK: Weed ecology, herbicide resistance.
- Principal Research Scientist, Rothamsted Research, UK: Programme lead for "Smart Crop Protection".
- Programme lead, Agriculture & Horticulture Development Board, UK: Integrated Pest Management.
- Professor, University of Copenhagen, Denmark: Weed ecology & evolution, One Crop Health.





#### **Overview of my presentation**

• The blackgrass epidemic in England: a motivating example.

• One Crop Health: What's the idea?

• One Crop Health: an international, interdisciplinary project.



# **Guardian**



Thu 12 Jun 2014 12.39 CEST



0

# Farmers frustrated by insidious black grass

**Lower Benefield, Northamptonshire:** At night, in the village bar, the name black grass is muttered darkly with shaking heads



Black grass, Alopecurus myosuroides, growing in wheat. Photograph: Tim Scrivener/Alamy



### The Blackgrass Resistance Initiative

Black-Grass Resistance Initiative





Rob Edwards Alina Goldberg-Cavalleri

Goldberg- Nawaporn Cavalleri Onkokesung

#### Molecular mechanisms & biochemistry





Ken Norris Alexa Varah

• Economic & environmental impacts





Lieselot Nguyen Laura Crook



Paul Neve David



**Richard Hull** 

David Comont Andrea Dixon



Claudia Lowe

• Ecology, evolution, population genetics & epidemiology





Rob Freckleton Dylan Childs Helen Hicks Shaun Coutts

• Evolutionary ecology, monitoring, modelling & epidemiology







Jarrod Hadfield

Quantitative
 genetics





Louise Jones

• Epigenetics

### A UK blackgrass farm network



- Field maps (spatio-temporal population dynamics)
- Seed samples (resistance characterization, molecular mechanisms, population genomics, fitness costs)
- Field management data
- Economic data (yields, costs, profit)
- Environmental data (soils, weather etc.)



SPECIAL ISSUE ARTICLE 🛛 🔂 Full Access

Adopting epidemiological approaches for herbicide resistance monitoring and management

David Comont 🔀, Paul Neve

#### Mapping blackgrass abundance



Field maps



Modelled national density maps, Hicks et al., 2021

#### **2014: A herbicide resistance epidemic**





**75% resistance90% resistance**Mesosulfuron-methylFenoxaprop-p-ethyl

56% resistance Cycloxydim

#### Resistance levels driven by herbicide use intensity

We looked for relationships between herbicide resistance and these common agricultural practices

#### Herbicide regimes

Herbicide intensity (applic. yr<sup>-1</sup>) \*\* Herbicide diversity (MOA yr<sup>-1</sup>) NS



Autumn vs spring sown **NS** Cereal vs other crop types **NS** Proportion w.wheat in rotation **NS** 



***	P < 0.005
VS	Not significant



Proportion of years ploughed **NS** Cultivation intensity score **NS** 



Evolution of resistance is driven only by intensity of herbicide use, no mitigation by herbicide diversity (mixtures, rotations, sequences) ecology & evolution

ARTICLES https://doi.org/10.1038/s41559-018-0470-1

#### The factors driving evolved herbicide resistance at a national scale

Helen L. Hicks<sup>1</sup>, David Comont<sup>2</sup>, Shaun R. Coutts<sup>1</sup>, Laura Crook<sup>2</sup>, Richard Hull<sup>2</sup>, Ken Norris<sup>3</sup>, Paul Neve<sup>2</sup>, Dylan Z. Childs<sup>1</sup> and Robert P. Freckleton <sup>3</sup>\*

#### Resistance costs up to €500 per hectare



Alexa Varah<sup>1</sup>, Kwadio Ahodo<sup>1</sup>, Shaun R. Coutts<sup>2,3</sup>, Helen L. Hicks<sup>0,2,4</sup>, David Comont<sup>5</sup>,

Laura Crook<sup>5</sup>, Richard Hull<sup>5</sup>, Paul Neve<sup>5</sup>, Dylan Z. Childs<sup>2</sup>, Robert P. Freckleton<sup>©2</sup> and Ken Norris<sup>®1</sup>

ROTHAMSTED RESEARCH

#### **Glyphosate sensitivity in UK blackgrass**



### Selection for glyphosate insensitivity



Research

The least sensitive populations have the longest and most intensive history of control with glyphosate = epidemiological evidence for creeping resistance.

Evolutionary epidemiology predicts the emergence of glyphosate resistance in a major agricultural weed

New Phytologist

David Comont<sup>1</sup> [0], Helen Hicks<sup>2</sup> [0], Laura Crook<sup>1</sup>, Richard Hull<sup>1</sup>, Elise Cocciantelli<sup>1</sup>, Jarrod Hadfield<sup>3</sup>, Dylan Childs<sup>4</sup> [0], Robert Freckleton<sup>4</sup> [0] and Paul Neve<sup>1</sup> [0]

#### NewScientist



#### Environment

# **Glyphosate-resistant weeds have evolved in the UK for the first time**

The herbicide glyphosate is helping farmers adopt more environmentally friendly practices, and resistant weeds will make this transition more difficult, experts say

#### By Michael Le Page

💾 10 January 2025

#### f 🗶 🔉 in 😎 🕿 🗬



Italian ryegrass is a common weed in arable crops

#### Variable sensitivity to a new pre-emergence herbicide







Research Article 🖻 Open Access 💿 🛈

The role of interspecific variability and herbicide preadaptation in the cinmethylin response of *Alopecurus myosuroides* 

David Comont 🔀, Laura Crook, Richard Hull, Bernd Sievernich, Stuart Kevis, Paul Neve



## 

#### UK herbicide use statistics (1992 – 2022)



Between 2012 and 2022, the total weight of herbicide active ingredients applied to UK arable crops has risen from 6,619 tonnes to 7,848 tonnes (pusstats.fera.co.uk)

### Herbicide resistance in UK blackgrass



- Epidemic of herbicide resistant blackgrass by early 2010's.
- Resistance has evolved rapidly and widely.
- Estimated annual costs of €0.5 billion
- Extent of resistance is determined by intensity of herbicide use.
- Resistance is conferred by multiple, co-existing mechanisms.
- No detectable fitness costs of resistance.
- Potential for resistance to glyphosate and newer pre-emergence herbicides.
- Herbicide use continues to increase (pre-emergence herbicides).
- We are selecting for a 'resistance syndrome' in major global weeds.
- Reducing reliance on herbicides is essential.

#### 2030 Targets for sustainable food production



Reduce by 50% the overall use and risk of chemical pesticides and reduce use by 50% of more hazardous pesticides





Reduce sales of antimicrobials for farmed animals by 50%



Achieve at least 25% of the EU's agricultural land under **organic farming** and a significant increase in **organic aquaculture** 



### **Reducing reliance on pesticides**





# **One Crop Health for Next Generation Crop Protection**

A six-year (2024–2030, €8 million) challenge grant from the Novo Nordisk Foundation

**AARHUS UNIVERSITY** 



novo nordisk **fonden** 



Department of Plant and Environmental Sciences



(Plant ecology and

evolution)

plants, microbes and the environment as a basis for the sustainable production of food and biological products. **Professor Paul Neve** 

PLEN focuses on







**Professor Jonathan Storkey** (Agroecology)



AARHUS UNIVERSITY

#### Department of Agroecology



The interaction between plants, soil, animals, climate and people. We develop sustainable solutions based on agroecological principles.

Professor Per Kudsk (Crop Protection)



AgZero+



**Professor Sune Darkner** (image analysis, digital twin technology)

9 Satellite Drones / Airplanes Proximity and Production Sensor In-Situ/ Research/ Samples 0 \*@

DIKU contributes to Agriculture of Data – a €332 million Horizon Europe Partnership

#### **One Health**



One Health is an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals and ecosystems.

It recognizes that the health of humans, domestic and wild animals, plants and the wider environment (including ecosystems) are closely linked and interdependent.



#### Human health & crop health: many parallels

- **Preventative** medicine prevention is better than cure
- Antimicrobial **resistance** / pesticide resistance / evolutionary context
- Precision medicine / precision agriculture
- Population surveillance / early detection / diagnostics
- Gene therapy / gene-editing / **new genetic technologies**
- Gut microbiome / plant-soil microbiome
- Evidence-based approaches & epidemiology
- Sensors / wearables / big data and AI

### Science breakthroughs for agri-food, 2030





Scientific advances in agroecology, sensors, data sciences & biotechnology will transform agri-food systems.

- **1.** A systems approach: understand nature of interactions in agricultural systems.
- 2. Field sensors and biosensors: enable rapid sensing and monitoring.
- **3.** Advanced analytics: integration of data sciences, software tools and systems models.
- 4. Gene editing: new biotechnology-inspired and enabled solutions.
- **5.** Microbiome: increase resilience to stress and disease.

### **One Crop Health: integration beyond IPM**

- Integrating plant heath, soil health & agroecosystem health.
- Integrating agroecological, digital, biological and biotechnological tools.
- Integrating biology & management pathogens, pests & weeds.
- Integrating prevention, detection & control.



#### **One Crop Health as an agro-eco-tech innovation**





#### **WP1: farm networks**

50 farms, 2 fields per farm (DK and UK) Focus on cereal – oilseed systems Monitor field-level presence, abundance, diversity of pests, weeds, pathogens, biodiversity. Integrate with field management and environmental meta-data.

- Epidemiological approach to determine environment (E) x management (M) drivers of PWD
- Understand which PWD complexes are associated with E\*M combinations.
- Optimise and integrate novel technologies for field to landscape monitoring and surveillance of PWD.





### **One Crop Health**

National farm
 monitoring networks

Large-scale, longterm field experiments

- Crop health systems
  models
  - An international cohort of PhD students

#### **WP2: Long-term field experiments**



\*Core measurements taken in baseline year and every third year \*\*Recorded every year

Li et al., Agronomy for Sustainable Development, 2023



### **WP2: farm networks**

Dynamic design (5 systems), 4year & 8-year crop rotations

- 1. Business-as-usual
- 2. Agroecological
- 3. Smart (digital)
- 4. Biological
- 5. One Crop Health

Reduce reliance on pesticides via integration of agroecological, biological & digital tools/approaches.





### **One Crop Health**

National farm
 monitoring networks

- Large-scale, longterm field experiments
- Crop health systems
  models
  - An international cohort of PhD students

### WP3: Crop health systems models





### **One Crop Health**

National farm
 monitoring networks

- Large-scale, longterm field experiments
- Crop health systems
  models
  - An international cohort of PhD students

### WP4: International PhD cohort

- 12 PhD projects funded
- Copenhagen University (5), Aarhus University (2), Roth/Sheffield (5)
- Surveillance & monitoring, soil-plantmicrobiome, modelling & data science, biocontrol, chemical ecology, agroecology.
- Cross-partner, international supervision
- Summer schools / workshops / seminars
- First call for applications in 2024/2025







### **Opportunities (pbneve@plen.ku.dk)**



Jobportal - Job og karriere på KU

- Videnskabelige stillinger
- Lektoropslag til forfremmelsesprogrammet
- Tenure-track-stillinger
- Ph.d.-stillinger
- Ph.d. på KU
- Undervisningsstillinger
- Administrative og forskningsunderstøttende
- stillinger KU som arbejdsplads Kontakt

#### PhD fellowships at the Department of Plant & Environmental Sciences.

The Department of Plant & Environmental Sciences (PLEN) is inviting applications for three PhD scholarships that will start on 1 September 2025 or later. The PhDs are funded as part of large international and inter-disciplinary projects in **One Crop Health** funded by the Novo Nordisk Foundation.

PLEN carries out research at the intersection of plant, agricultural, environmental and biotechnological science to develop novel approaches and solutions for the green transition of agri-food and environmental systems. The PhDs will be based in the sections of crop sciences, organismal biology or microbial ecology and biotechnology at PLEN.

#### Deadline: 29 April 2025

Jobportal DK > Ph.d.-stillinger

#### Start date: 1 September 2025

 Harnessing environment DNA (eDNA) for surveillance and management of agro-biodiversity.

ONE

HEALTH

- The impact of functional biodiversity in weed-insect interactions.
- Breaking the bank: Weed seed bank decay in arable soils.
- Fungal induced resistance against cabbage stem flea beetle in oilseed rape.
- Integrated control of airborne diseases in wheat.

#### The One Crop Health project (DK, UK) is looking to collaborate in upcoming Horizon calls in plant health and IPM!!



# Bedankt