SESSION 6

PESTS INSECTS

K4 Sustainable management of wireworms in potato production: on-going research towards a comprehensive approach
Yves Le Hingrat (inov3PT, France)

O19 Wireworm : An update on recent UK work
Martyn Cox (Blackthorn Arable Ltd, United Kingdom)

O20 Wireworms at the northern margin of potato production in Europe - improved monitoring and pest control in Norway
Annette Schjøll (NIBIO, Norway)

O21 Ecobreed: Evaluating wireworm (Coleoptera: Elateridae) control strategies in potato
Eva Praprotnik (Agricultural Institute of Slovenia, Slovenia)

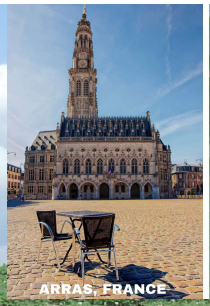
O22 Distribution and flight activity of wireworms (*Agriotes* sp.) in Austria
Vitore Shala-Mayrhofer (Austrian Chamber of Agriculture, Austria)

O23 Potato varietal susceptibility to wireworms (*Agriotes lineatus*) in relation to their sugar and glycoalkaloid profiles
Bruno Ngala (inov3PT, France)

O25 Studying Colorado Potato Beetle resistance in wild Solanum species
Lotte Caarls (WUR, The Netherlands)

P27 Tillage and cover crops as strategies to control wireworms' populations before a potato crop
Arnaud Barbary (Bretagne Plants Innovation)

P28 PacBio amplicon sequencing of *Ry_{sto}* homologues in wild potato species
Zhimin Yin (IHAR-PIB, Poland)



Sustainable management of wireworms in potato production: *on-going research towards a comprehensive approach*

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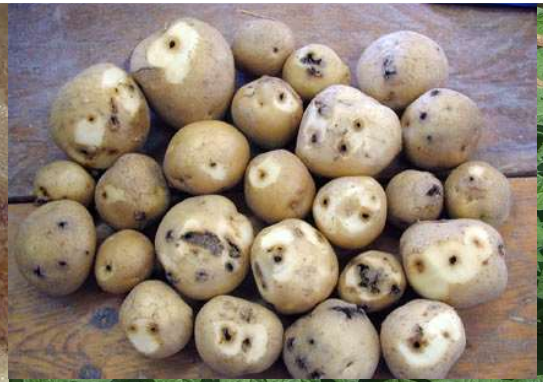
Avec la contribution financière du compte d'affectation spéciale développement agricole et rural CASDAR
MINISTÈRE DE L'AGRICULTURE ET DE L'ALIMENTATION

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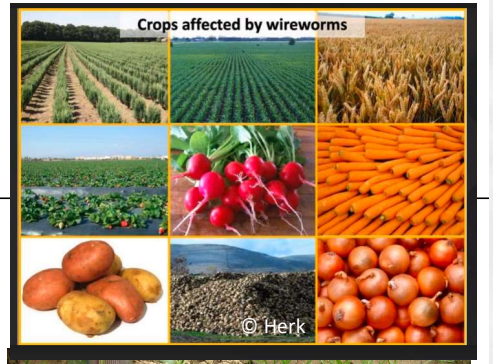
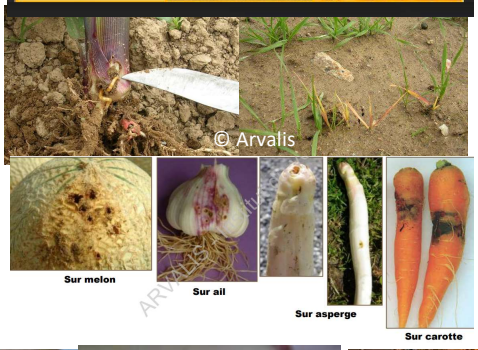
Introduction and context

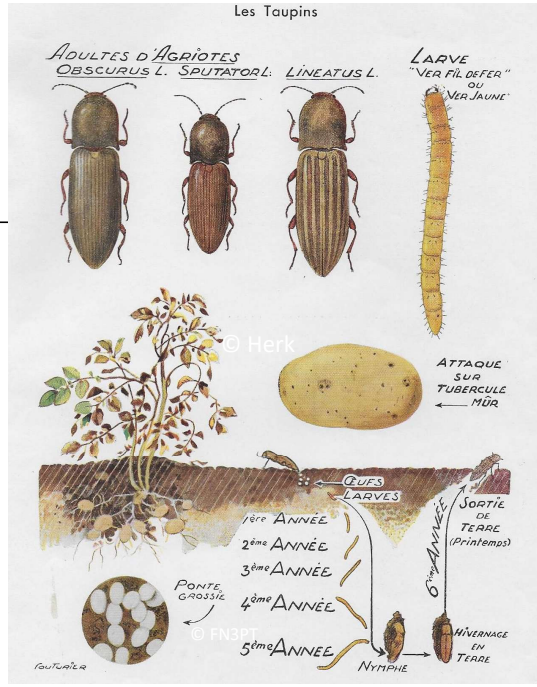
WIREWORMS

An old issue... that is back on the agenda

- **Wireworm**s, the larvae of click beetles (Coleoptera, Elateridae), are extremely **polyphagous pests** and feed on nearly all cultivated (cereals; vegetables including onions, leek and garlic; maize; potatoes; ornamentals, sugar beet..) and wild plant species, including weeds (Poggi et al, 2021).
- Nearly 10,000 described species (Traugott et al, 2014) with most harmful species belonging to the genus ***Agriotes*** *: A. lineatus, A. sordidus, A. sputator, A. obscurus, etc.*
- Life cycle 1 to 11 years (Le Cointe et al, 2023)=> **importance of rotation**
- **Strong economic impact for the potato industries,** due to holes and galeries digged by larvae in tubers
  - **At the production level:** downgrading or rejection of affected lots, sorting costs
  - **at the commercial level:** complaints from end-users, customer change, etc.
- **Strict tolerance on seed potatoes => UNECE Standard S-1:** *Tolerance for Pest damage (e.g. slugs, wireworms, tuber moth, flea beetles):* ***<4 % by weight of the seed lots*** (*tubers with more than 10 holes or more than 3 holes of 5 mm in depth)*





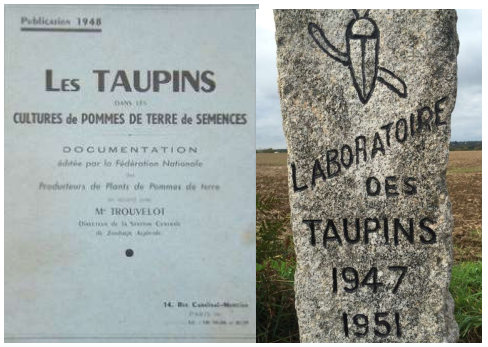


inov3PT
SEED POTATO
FOR THE FUTURE

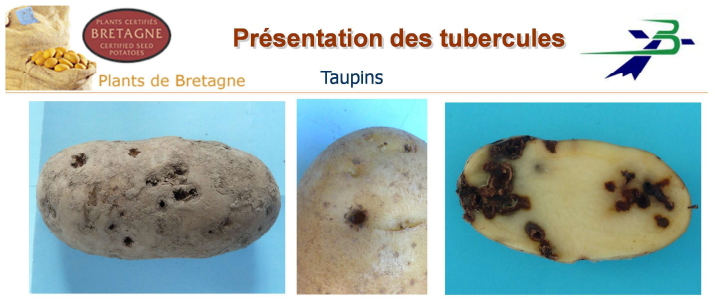
WIREWORMS

INCREASING ECONOMIC LOSSES

- **(Re)increased risk factors** : withdrawal of effective soil insecticides for environmental concerns (European Green Deal; SUR: New Regulation on the Sustainable Use of Plant Protection Products..), evolution of crop management (Simplified Cultivation Techniques, cover crops), etc.



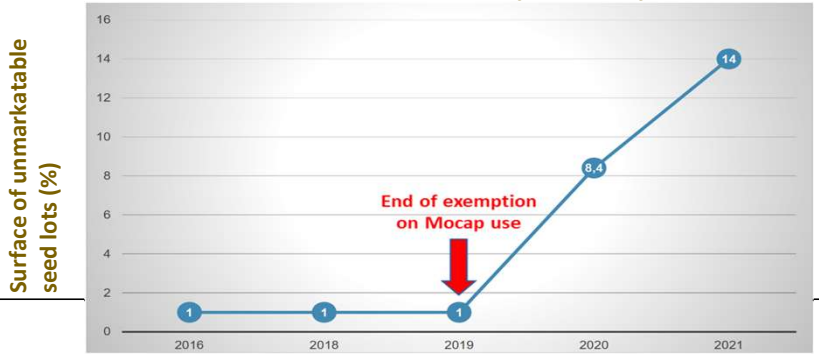
Past wireworm field laboratory in Brittany (INRA-FNPPPT)



- **Leading to increasing damage and decreased quality** :
  - For both ware and seed potato production
  - Case study in Britanny on seed potatoes 2020-2021:
    - +**60% of harvested lots with holes** in some areas
    - **14% lots non compliant** with tuber tolerances
    - E**conomic impact around 3-5** M€ /year
  - Increase also in other potato production areas

European Green Deal

Unmarketable tuber lots(%): Case study – Brittany, France (Bretagne-Plants)



- **Need to find soon sustainable solutions**

Wireworms impact and management on potato production

Brief overview and insights from 2023 survey

Survey on wireworms impact, management and pririty on potato production

Brief overview and insights from 2023 survey

SURVEY on WIREWORMS on POTATO production and marketing

OBJECTIVES

- **Acquiring and sharing knowledge** on wireworms in potatoes at international level :
  - **Economic impact on potato farming**
  - **Management measures**
  - **Research challenges**
- **Building a common vision** for the development of alternative solutions and effective management strategies **for the integrated protection of 🥔🥔🥔 crops!**
- Survey sent by inov3PT (June 2023) to a large panel of partners and people involved in potato research, production or marketing

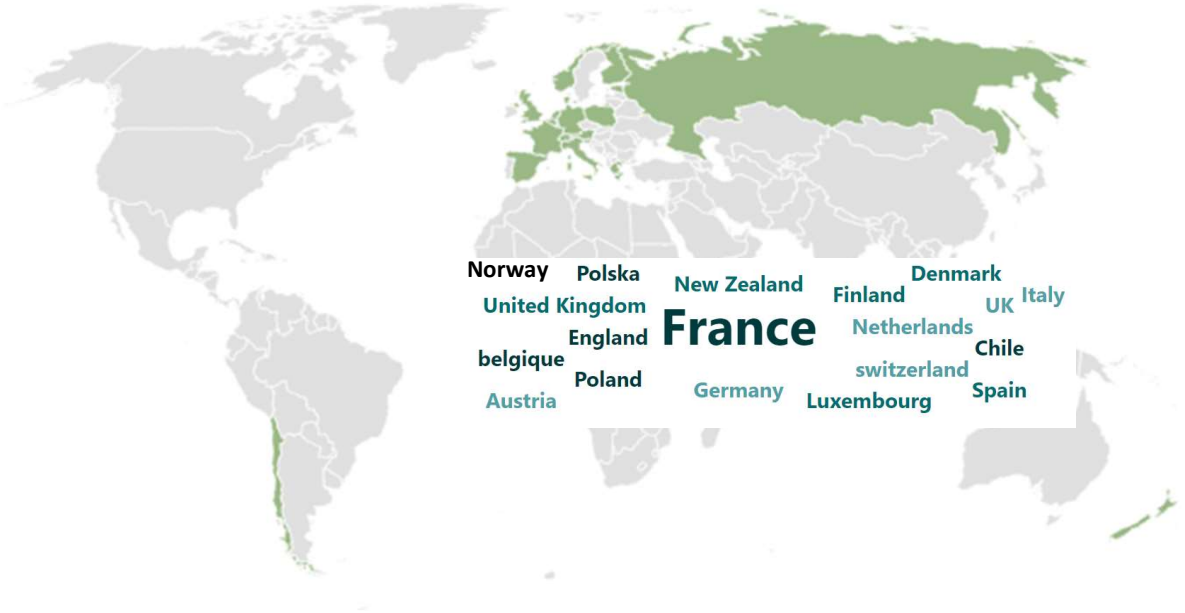
Online survey accessible through the link :
https://forms.office.com/e/tDPpMryJrv
or QR code :

SURVEY on WW :

PANEL OF RESPONDANTS

Around 60 contributions from 17 Countries :

- 14 in Europe (FR, BE, UK, NL, AU, CH, DK, EE, ES, FIN, GR, IT, NO, PL)
- 3 other countries (NZ, RU, CL)

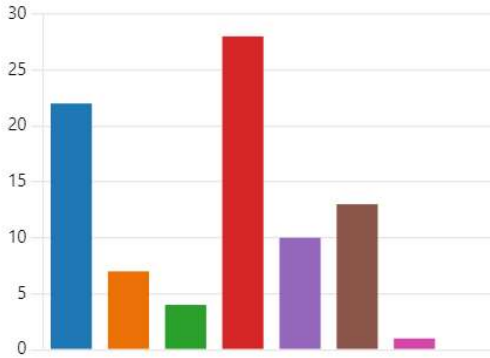


A diversified panel : potato organisations, R&D, seed companies, ..

2. What is your field of activity ?

Plus de détails

Research	22
Breeding	7
Institutional or public authorities	4
Potato production (growers & p...	28
Agricultural consulting and R&D...	10
Potato marketing, seed compani...	13
Supplier (plant protection produ...	1
Other	0



Research
Breeding
Institutional or public authorities
Potato production (growers & professional organisations)
Agricultural consulting and R&D, extension service
Potato marketing, seed companies, industry
Supplier (plant protection solutions, equipment, ..)
Other... ...

Thanks for their time and valuable contribution

SURVEY on WW :

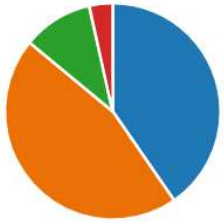
IMPACT ON POTATO PRODUCTION

Nearly 90% of respondants consider wireworms as an important or very important danger for potato production

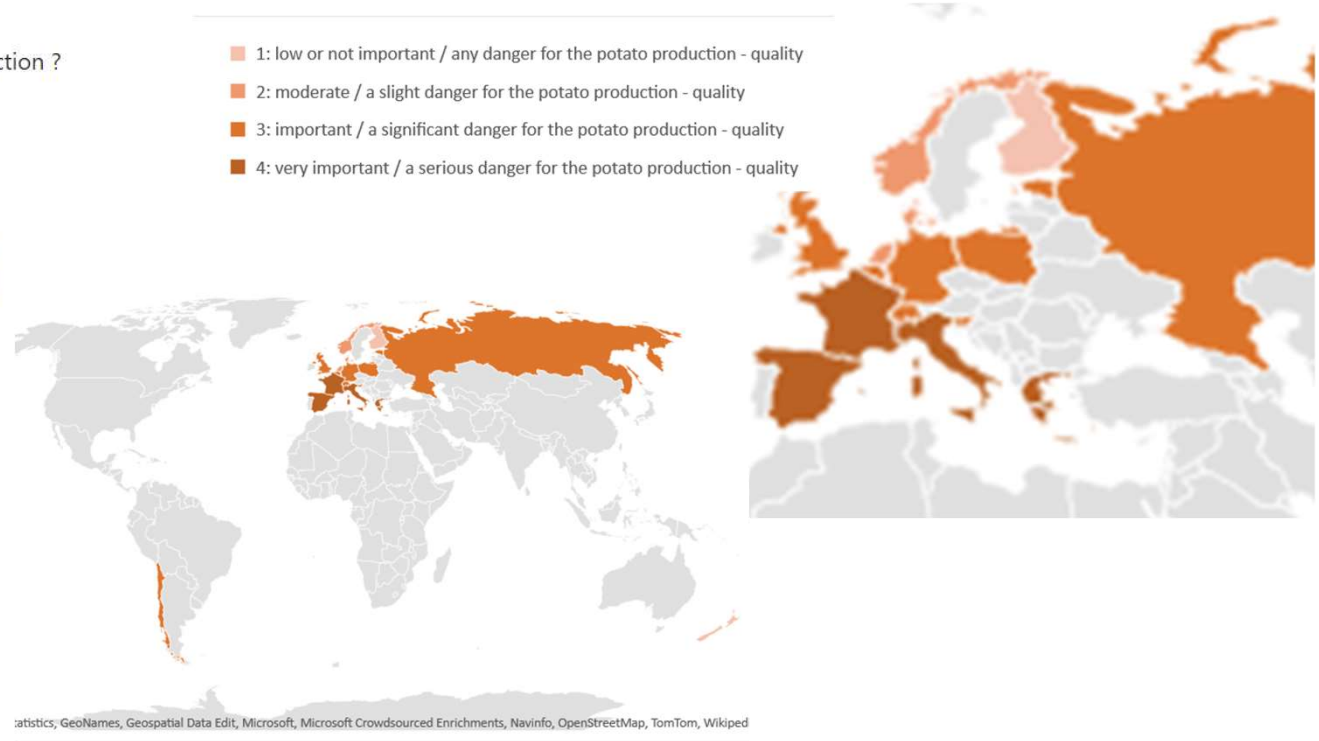
4. How do you consider the economic impact of wireworm damage on potato production ?

Plus de détails Aperçus

4: very important / a serious da...	23
3: important / a significant dang...	26
2: moderate / a slight danger fo...	6
1: low or not important / any da...	2
0: I don't know	0



High impact in most countries, with variable pressure



SURVEY on WW :

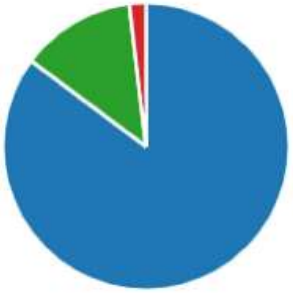
EVOLUTION OF IMPACT ON POTATO PRODUCTION and SUGGESTED REASONS

Increasing damage in the past years

Firstly related to low efficiency of allowed insecticides but also to changes in crop management (low tillage, cover crops,..) and climate change

5. Have you noticed any changes in wireworm damage on potato crops over time?

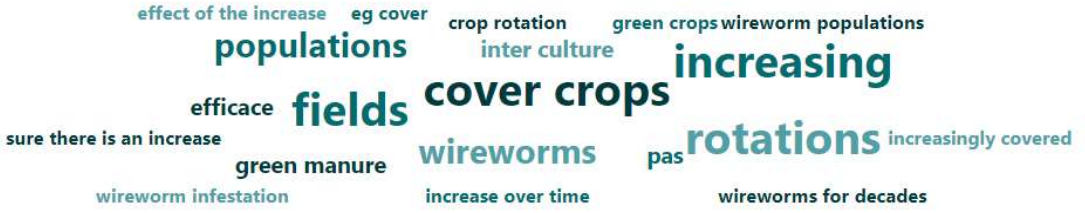
Yes, an increase in the past years	46
Yes, a decrease in the past years.	0
No, rather the same damage in ...	7
I don't know	1



6. If yes, what is the reasons for this change in wireworms damage

Low efficiency of allowed insecti...	36
Changes in crop management p...	22
Climate change	20
Others (to be specified)	6

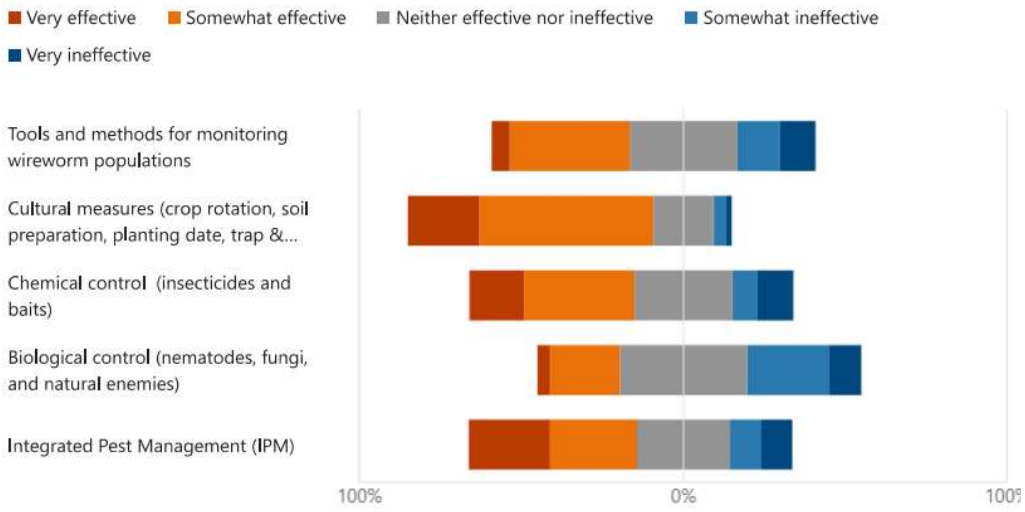
7. If you think of other reasons for this change in wireworms damage, could you specify ?



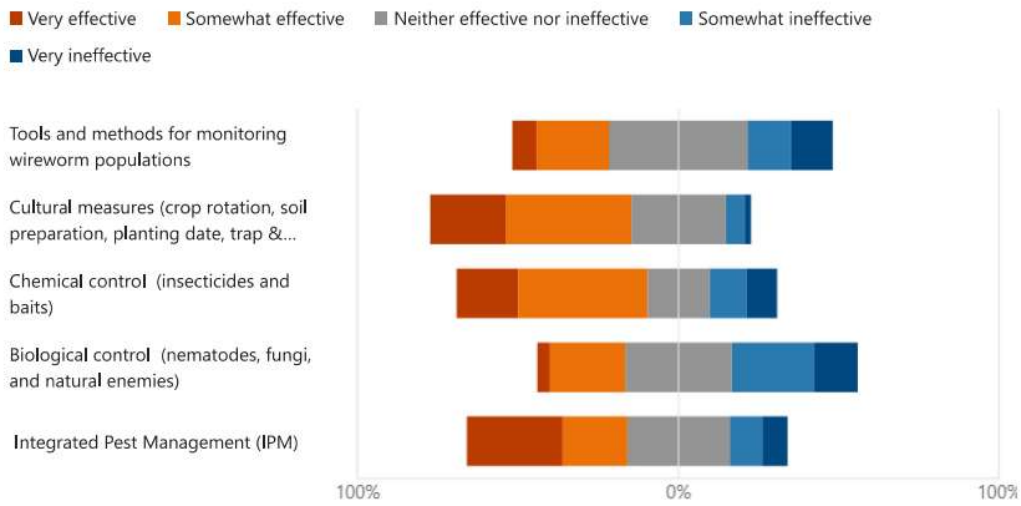
SURVEY on WW

OPINION ON THE EFFICIENCY OF MANAGEMENT MEASURES

8. How effective do you consider these measures in controlling **wireworm infestation** ?



9. How effective do you consider these measures in **controlling wireworm damage** to potato tubers ?

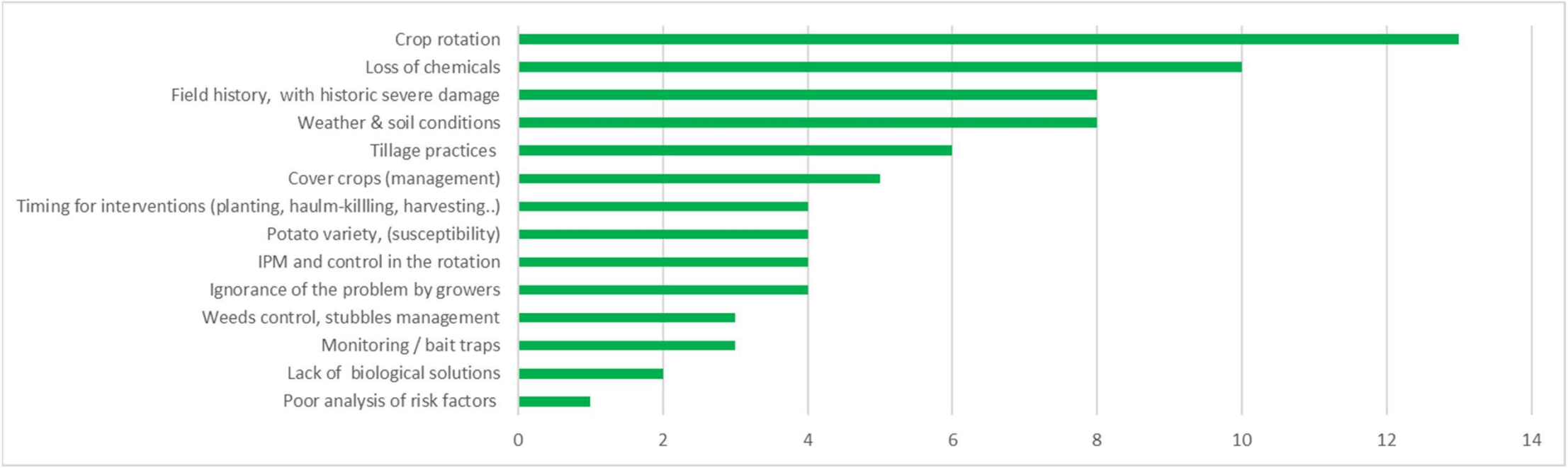


Cultural measures, IPM and chemical control are considered as the most effective current measures
Biological control is still far behind

SURVEY on WW :

FACTORS INVOLVED IN EFFICIENCY WW MANAGEMENT

10. What factors contribute most to the success or failure of wireworm management in potato production?



Main cited factors are Crop rotation, cultivation practices, weather & soil type, susceptibility of varieties, etc.

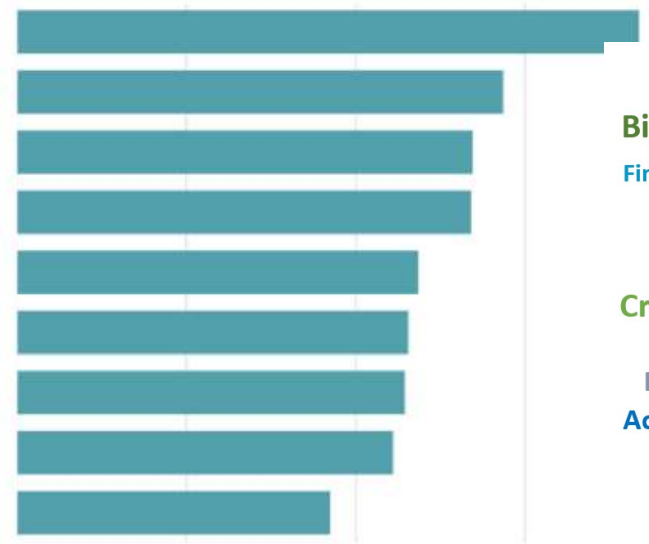
SURVEY on WW :

PRIORITIES AND RESEARCH CHALLENGES

Research expected on many subjects :
Biology of wireworms, risk assessment, biocontrol solutions, agronomy, IPM, varietal tolerance, etc..

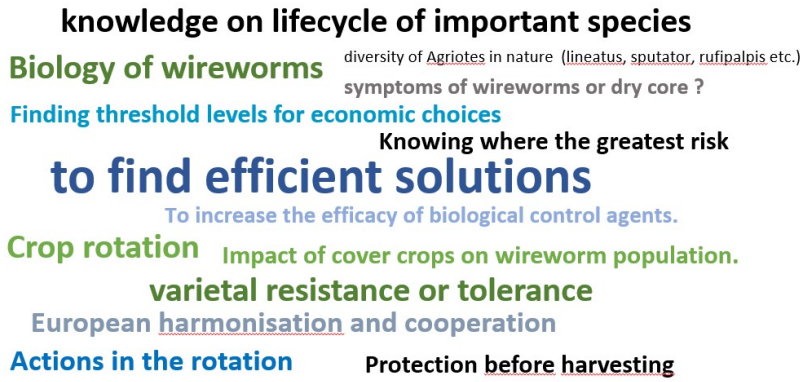
13. What research areas should be prioritized to improve wireworm management in potato production?

1) Biology and knowledge on wireworms
2) Risk assessment, bait trapping, decision support systems
3) Development of biocontrol solutions
4) Agronomical (soil preparation, trap or cover crops))
5) Integrated Pest Management (IPM)
6) Rapid identification tools
7) Crop duration, previous crops in the rotation
8) Varietal resistance or tolerance
9) Physical or mechanical control



With high expectations to find new SOLUTIONS

14. What are for you the most significant research challenges in wireworm management for potato production?



SURVEY on WW :

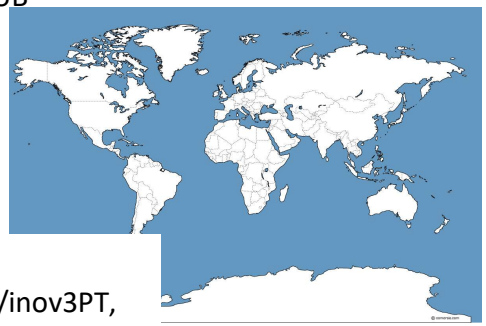
SOME ON-GOING (OR RECENT) RESEARCH ON WIREWORMS

Many recent initiatives in Europe

UNITED KINGDOM:
- ENIGMA« *Sustainable wireworms IPM* » 2022-2024. FERA + partners (Blackthorn Arable, potato & vegetables sector, Syngenta, inov3PT)
- Swansea University - Natural Products BioHUB Harper Adams University
- CUPGRA, Rothamsted research…

NORWAY : Project « ANIBIO, *Improved monitoring and control of wireworms in Norwegian potato production* (end Dec. 2022, potential follow-up project)

ESTONIA : Project « Alternative methods in control of wireworms on potatoes." Funder: Estonian Agricultural R&I Board



NETHERLANDS : Dutch project "Grondige aanpak bodemplagen (*Thorough approach to soil pests*)" 2022-2025; WUR + partners (potato, beet, bulbs..)

BELGIUM :
- Gembloux Agrobiotech (VOCs)
- FIWAP/ CARAH/CRAW

GERMANY : *Alternative Strategies for Controlling Wireworms in Field Crops*: Julius Kühn-Institute, BIOCARE

FRANCE:
- TAUPIC (*collab. project on ww/potato*) FN3PT/inov3PT, OP (BPI, CN, CCS), INRAE, ARVALIS, FREDON; 2020-2024
- TAUPIN-LAND (ww/*maize*); ARVALIS, Semae; 2021-2023
- OPTI-NEP (*biocontrol EPN*) INRAE, ACTA, ELISOL, ROUILLIER 2022-2024
- STARTAUP (INRAE, ARVALIS, AGRIAL, MFR, 2018-2020)

+ internal projects (e.g. Bretagne-plants, ..)

AUSTRIA : Project '*Practice-based and sustainable regulation of wireworms* 2020-2026'. AGES, Uni Innsbruck, Meles..

SWITZERLAND : Agroscope (projects *Microbial Pest Control* & B*iocontrol Agents Against Plant Diseases and Pests*); FiBL (project '*Wireworm damage mitigation strategies*' 2021-2024)

ITALY: *Identification and IPM on Agriotes,* Veneto Agricoltura, CREA-CI, UNIFE..

- ELATPRO (Era-Net C-IPM, 2016-2019) "*Spotting the needle in a haystack - Predicting wireworm activity in top soil for integrated pest management in arable crops*" AGES (AU) + 14 partners : AU, BE, FR, GE, CH.
- ECOBREED (H2020, 2018-2023): *Increasing the efficiency and competitiveness of organic crop breeding*. Coord. Agricultural Institute of Slovenia + partners from 15 countries: AT, CN, CZ, DE, ES, GR, HU, IT, PL, RO, RS, SI, SK, UK, USA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Focus on some advances of the French collaborative TAUPIC project 2020-2024

- ipartly supported by a research grant from the French ministry of Agriculture / CasDAR (Call Casdar 2020 « *Recherche technologique pour la compétitivité et la durabilité des filières de la production à la transformation* »

Avec la contribution financière du compte d'affectation spéciale développement agricole et rural CASDAR
MINISTÈRE DE L'AGRICULTURE ET DE L'ALIMENTATION
Liberté Égalité Fraternité

Projet TAUPIC 2020-2024

" Risk assessment and innovative tools for integrated potato crop protection against (*Agriotes* sp.) wireworms damage "

FN3PT/inov3PT, ITA coordination

INRAE-UMR IGEPP team EGI

FREDON Hauts-de-France

Regional organisations of seed potato growers

Arvalis

Subcontracting : University of Liège-Gembloux Agro Bio Tech (VOCs)
Midi Agro Consultant,
Astria (field trials)

Project labelled by UMT InnoPlant²

In association with surveys contributors, biocontrol companies, breeders, etc.

1. Improving the risk assessment of wireworm infestation and damage to potato crops

IMPROVING THE RISK ASSESSMENT OF WIREWORM INFESTATION AND DAMAGE

What are the main risks factors ?

INPUTS FROM ADVANCES IN MAIZE

Typology of fields and farming practices linked with larval infestation and damage

Smart Agricultural Technology 4 (2023) 100162

Contents lists available at ScienceDirect

Smart Agricultural Technology

journal homepage: www.journals.elsevier.com/smart-agricultural-technology

A decision support system based on Bayesian modelling for pest management: Application to wireworm risk assessment in maize fields

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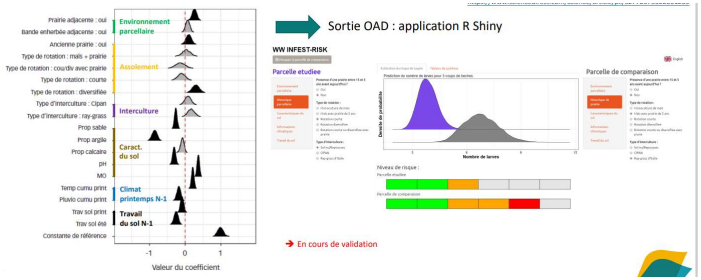
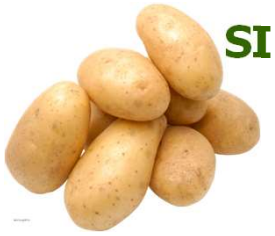
https://www.sciencedirect.com/science/article/pii/S2772375522001265



IMPROVING THE RISK ASSESSMENT OF WIREWORM INFESTATION AND DAMAGE

What are the main risks factors ?



SIMILAR APPROACH ON POTATO / Typology of fields and farming practices linked with larval infestation and damage

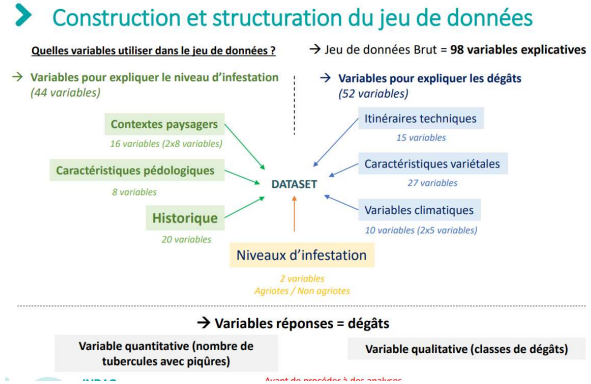
1.1. National surveys conducted with potato farmers to better assess the risks factors

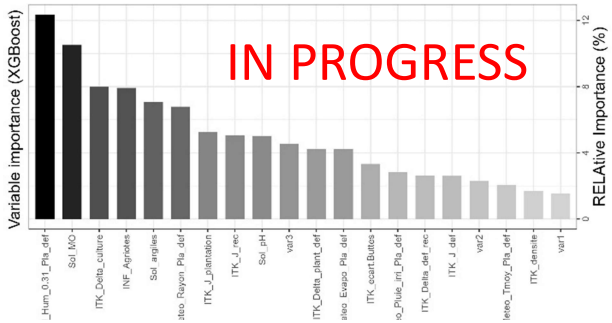
Partners : Inrae-Igepp, FN3PT-inov3PT, 3 OP (Bretagne-Plants, Comité Centre-et-Sud, Comité Nord), Arvalis

359 surveys conducted in 2021 and 2022 (variable WW infestation)

Data collected on tuber damage, wireworms (species, abundance), soil type, cropping itineraries, weather ...

Localisation des parcelles enquêtées en 2020





PRELIMINARY RESULTS :

multifactorial (41 variables = 90% of total significance):

e.g. variables with significant influence on damage =>

- *weather between planting and haulm-killing,*
- *organic matter content, soil texture (% clay), pH,*
- *Agriotes larvae infestation levels,*
- *number of days between planting and harvest, etc.*

IMPROVING THE RISK ASSESSMENT OF WIREWORM INFESTATION AND DAMAGE

What are the main risks factors ?

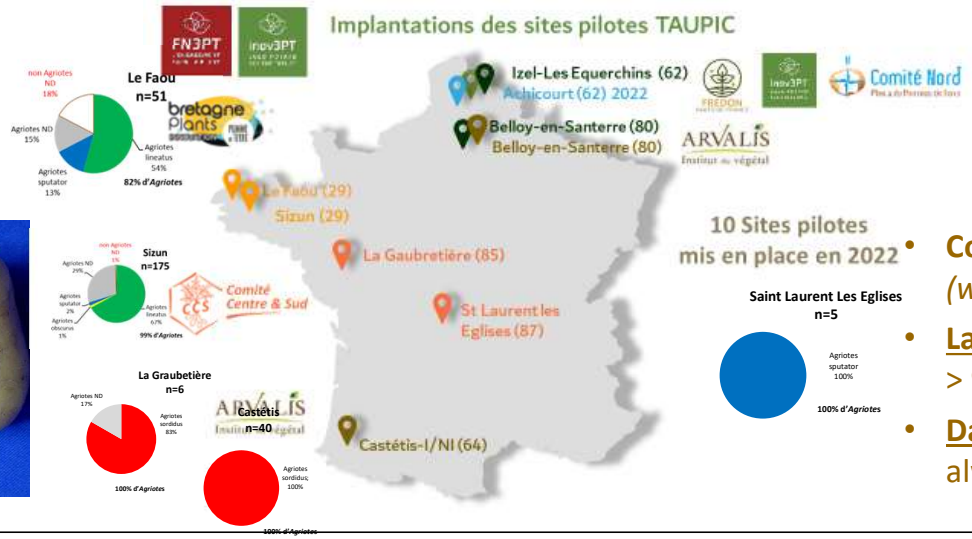
1.2. In-depth spatio-temporal monitoring of pilot sites :

Partners : Arvalis (coordination), FN3PT-inov3PT, 3 OP (Bretagne-Plants, Comité Centre-et-Sud, Comité Nord, FREDON

Kinetics of wireworm presence and attack during growing season on 10 pilot-sites: **level o infestation and species present,** sampling during cultivation and at harvest to record **damage,** and **data collected** (cultivation practices, soil type, weather..) in order **to improve risk forecasting**

Soil sorting

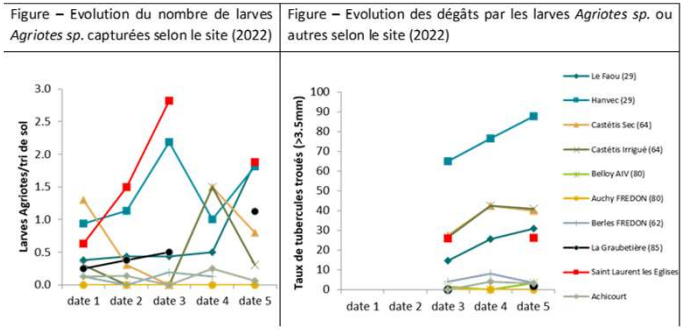
Tuber damage



RESULTS IN PROGRESS

Evolution during potato growing (2022) of

a) Wireworms infestation **b) Tuber damage**



- **Contrasting situations** between sites and dates *(weather, damage, larvae abundance, species)*
- **Larvae abundance**: significant in 50% sites; *Agriotes* > 95% of larvae collected around damage
- **Damage**: more with high ww infestation (not always !)

IMPROVING THE RISK ASSESSMENT OF WIREWORM INFESTATION AND DAMAGE

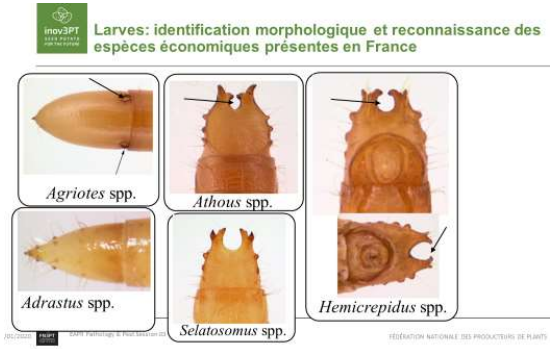
What are the diversity and risks of the current wireworms populations in potato fields ?

1.3. Characterisation of current wireworm populations in potato fields

Partners : INRAE-IGEPP, FN3PT-inov3PT

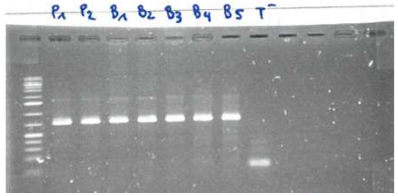
Characterisation tools used

Morphological identification (complex)



Molecular tools

- **PCR multiplexe** for 4 main *Agriotes* species (INRAE)

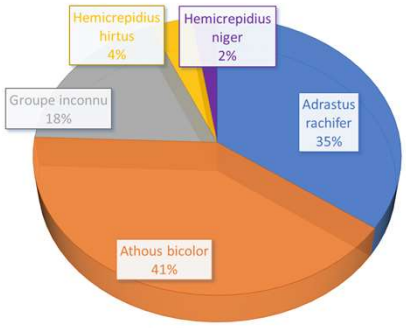


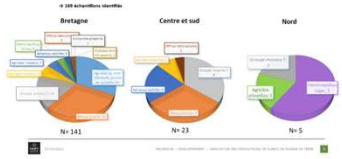
- **DNA Barcoding**, for broader identification of wireworms species (inov3PT)

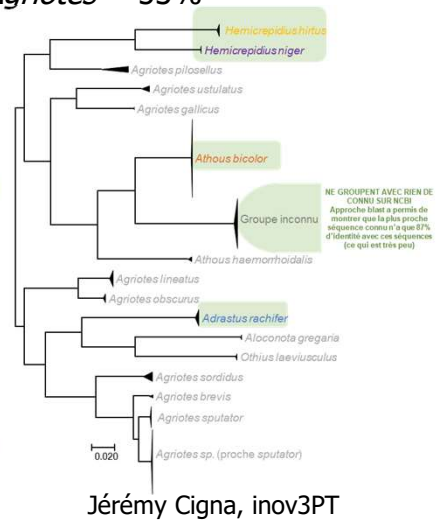
A wide diversity of WW populations with # impact

- **On field soils collected from surveys**

Agriotes = 47% ; non *Agriotes* = 53%







Jérémy Cigna, inov3PT

- **On potato tubers and adhering soil** :

Agriotes = 83% in potato trials; > 95 % in storage


© Y.Blot - INRAE

2. Development of novel solutions to prevent and reduce wireworms infestation and damage

- ***Field trials and laboratory studies***

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FOR THE FUTURE

SOLUTIONS TO PREVENT / REDUCE WIREWORM INFESTATION AND DAMAGE

What are the practical results of BCA in potato fields ?

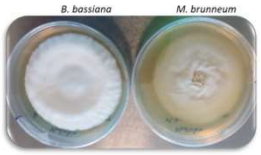
2. Developing and testing novel and durable solutions: IN FIELD..

***Partners**: Arvalis (coord.), Bretagne Plants Innovation, Fredon Hauts de France, Midi Agro Consultant, Astria,*

ARVALIS ASTRIA · bretagne plants innovation · FREDON HAUTS-DE-FRANCE · MidiAgro CONSULTANT

Field evaluation of biocontrol solutions to protect potato tubers :

- **A network of potato field trials** (6 sites) to test biocontrol solutions
- **More than 20 conditions tested** in 2021 and 2022, alone or combined (Push & Pull)



MICROBIALS - Entomopathogenic FUNGI (EPF)

- *Beauveria bassiana* (Naturalis)
- *Metarhizium : M brunneum (*Attracap), *M.anisopliae* (Met52) + other BCA

MACROBIALS - Entomopathogenic NEMATODES (EPN)

- Cf. project OptiNEP
- Vitrotests (*Steinernema carpocapsea, S. feltiae, Heterorhabditis bacteriophora*)

PLANT EXTRACTS & NATURAL SUBSTANCES (Repellent or insecticides)

- Extracts from garlic, peppers, mustards (Biofence, Tapis vers), etc.
- Organic products

COMBINATION WITH ATTRACTION STRATEGIES

- Companion or bait plants (barley, buckwheat, oat, etc)
- Combinations with BCA

SYNTHETIC RESULTS :

- **Efficiency highly variable (0% to 45%)**
- **Poor efficiency for high ww infestations**
- **Some interesting results with low or medium ww infestation**
- **Variability in efficiency of biological solutions** in relation with the environment (soil, climate..), the product dose, timing of application**..**
- **Interest of combination approaches**

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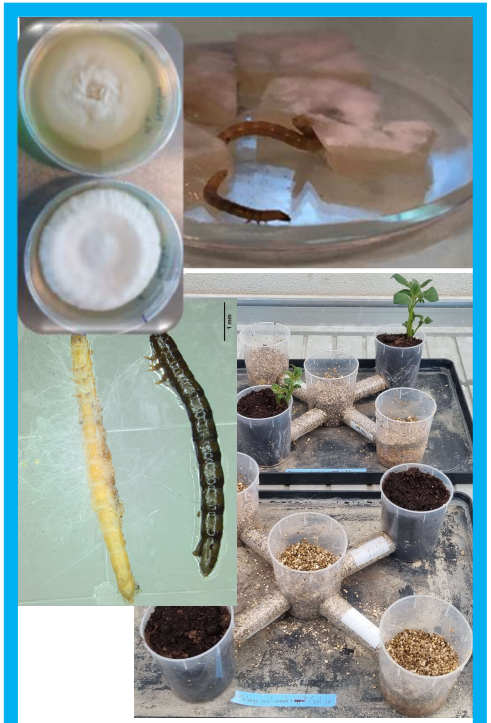
FOR THE FUTURE

SOLUTIONS TO PREVENT / REDUCE WIREWORM INFESTATION AND DAMAGE

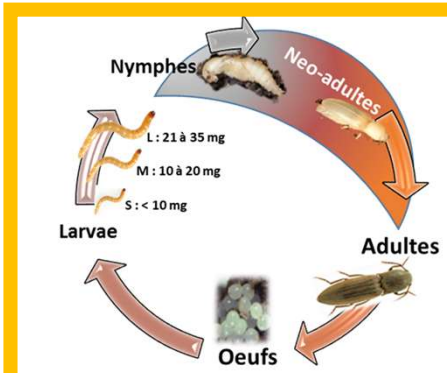
How to speed up the development and knowledge of BCA in potato ?

2. Developing and testing novel and durable solutions in CONTROLLED CONDITIONS (INOV3PT)

Wireworms rearing for screening & biology studies



Screening of biological solutions on larvae



Larval stage vulnerability

Varietal susceptibility

Testing (cover) crops and wireworms damage on subsequent potato

Photos: B.Ngala & F.Manceau

SOLUTIONS TO PREVENT/REDUCE WIREWORM INFESTATION AND DAMAGE

What about the potato varieties ?

Integrating palatability and tolerance of potato varieties

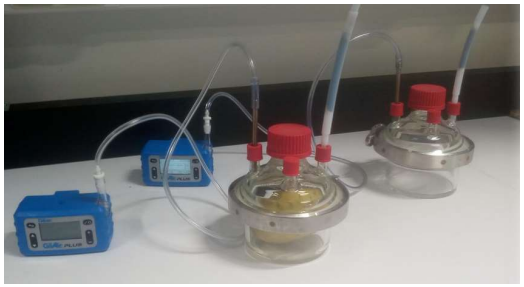
***Partners**: Bretagne Plants Innovation, inov3PT, Arvalis, ULG-BE*

= upcoming communication of Bruno NGALA

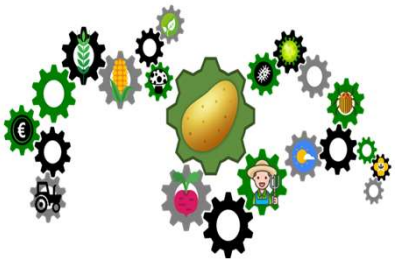
- **Field evaluation** - (Bretagne Plants Innovation)
- Studies in **controlled conditions** (inov3PT)

- **Identification of volatile organic compounds (VOCs) emitted by potato lots.** (Arvalis/Université Liège)

Ruhland F, Chacon C, Boullis A, Verheggen F (2022). The best potato: Evaluation of wireworm varietal preference. Presentation at ESA 2022 Joint Annual Meeting, Vancouver, Canada



SUMMARY and PROSPECTS



© C.Puech, inov3PT

- Evidence of wireworms population increases and damage levels on field potato crops
- Need to more efficient and reliable solutions available to farmers

- Alternative solutions have often low to medium efficiency when WW infestation is high
- Many risk factors are known (cropping system, soil cultivation, soil infestation, weather, etc.) and recent advances in their hierarchy
- Some progress with research on wireworms (biology, detection, risk assessment, screening, etc.)

- Sustainable management of wireworms should rely on a global approach:
- 1) combining measures (biocontrol solutions, baiting strategies, soil tillage, variety choice..)
- 2) protection designed at the rotational scale and innovative cropping systems

- **Renewed interest and research on wireworms**
- **This EAPR - Wireworms session is a good opportunity to share advances and maybe to set up future collaborations or concerted actions**

Thanks for your attention !

and to the partners of Taupic project:

INOV3PT

Yves Le Hingrat
Project coordination


Bruno Ngala & Florian Manceau
Studies in controlled conditions (Achicourt)

Jérémy Cigna
Development of molecular tools (barcoding)

Camille Puech Cropping systems

Michel Malet
Technical support

Regional Organisations of Seed Potato Producers (POs)

Field trials, pilot sites, surveys..

Philippe Dolo & colleagues

Sébastien Vast…

Philippe Laty..

INRAE-IGEPP




Pierre Lantrin, Ronan Le Cointe, Sylvain Poggi, Manuel Plantegenest
(coordination of surveys and risk assessment)

ARVALIS

Philipe Larroudé
Jean-Baptiste Thibord


Coordination of action 2, field trials and of the network of pilot sites

FREDON HdF

Amandine Mollet, Lucien Culiez, Salomé Joubert
Field trials; pilot sites

ULG-ABT

François Verheggen, Fanny Ruhland, C. Chacon, Antoine Boullis
Volatile Organic Compounds

Avec la contribution financière du compte d'affectation spéciale développement agricole et rural CASDAR
MINISTÈRE DE L'AGRICULTURE ET DE L'ALIMENTATION

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Wireworm : An update on recent UK work

Martyn Cox Blackthorn Arable Ltd

INNOVATIVE FARMERS
PART OF THE DUCHY FUTURE FARMING PROGRAMME

ENIGMA
A fera led collaborative R&D model fera

CUPGRA
Cambridge University Potato Growers Research Association

Content for today

- Project introduction
- Background to the UK situation
- Current UK projects

- **Wireworm background**
  - Details of the species we have

- **The problem and why its getting worse again**

- **Risk assessment**
  - Landscape
  - Monitoring adults & larvae

- **Strategy**
  - Potato varieties
  - Control options

- Summary

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Some background

- For many years, wireworms were only a problem after grass.
  - About 25 years ago, we started to see problems again.
  - Named arable wireworm (not linked to grassland).
  - Research into the situation, mainly Parker with others

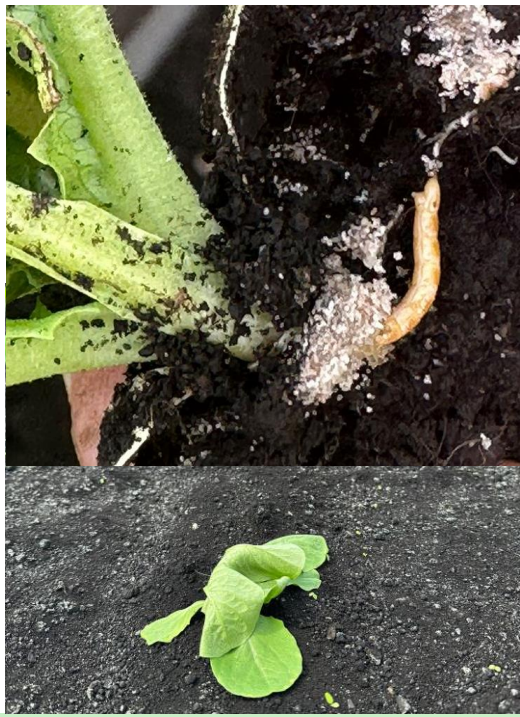
- Last major study on species was 1938-42
  - No recent data on our species mix.

- No concept of control in the rotation.
  - Everything was control in the crop
  - In 2020, we lost Ethoprophos and our problems increased.

The situation now

- UK potato growers now have no effective insecticides to control this pest

Potato packer	Comments
A	1500 tonnes rejected, 2% of total
B	14% of loads had damage
C	21% of loads had damage
Reports of loads with up to 80% damaged tubers	



- The situation is worst in the south of the UK
- Problems also being seen in lettuce, onions, cereals, maize, and brassica transplants.
- Interestingly, parsnips never seem to get damaged!

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Some background

- Since 2020 we only have fosthiazate, with 119 days harvest interval.
  - It only gives around 20% control
  - Nothing in early harvested crops.
  - Suddenly problems got much worse.

- One large grower would treat 40% of his potatoes with Ethoprophos.
  - They used 11.5 tonnes of product per year.
  - Now they do not treat any, IPM is working for us.

  - But not with regenerative methods yet.

Some background

- For 20 years I have been managing this pest in potatoes
- Inspecting crops before harvest helped us save many
- It also helped us learn where the pest would be
- Many thousands of hectares checked.
- Invaluable knowledge!

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Current UK research

- More focus on understanding the pest
  - The species and life cycle (Fera Enigma project in particular)

- How to manage in a rotation
  - Innovative Farmers field lab

- Risk assessments, detection.

- Variety differences, and why they differ
  - Cupgra research

- Management options

Fera: Enigma Wireworms

ENIGMA
A fera led collaborative R&D model fera

- Launched in 2022 with industry funding
- Enable accurate identification of click beetle adults and larvae.
- Develop DNA barcoding methods for the UK
- Improve knowledge of life cycle critical stages
- Breed larvae and conduct cover crop feeding studies
- Multi site pheromone trap network in the UK 2023 for Agriotes




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CUPGRA: Variety tolerance

CUPGRA
Cambridge University Potato Growers Research Association

In association with
NIAB CUF
UNIVERSITY OF CAMBRIDGE

- Cupgra wireworm review 2022
- Work now focused on variety susceptibility
- And the reasons for these differences.

- Glycoalkaloid level unlikely to be a major factor.
- Work this year will investigate a range of varieties and all will be tested for sugars and glycoalkaloids

- Varieties also respond differently to wireworm feeding, why?

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Innovative Farmers: Field lab

- Identify survival of larvae during Autumn under different strategies
  - Bare soil or barley volunteers
  - Cultivate or not?
  - Buckwheat or mustard cover crops, biofumigate or not.

- Aims to identify the level of young larvae in Autumn 2023 and spring 2024
- Samples taken for extraction by ADAS
- Survival of juveniles appears to be a key part of the increase in populations

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Pest species in the UK

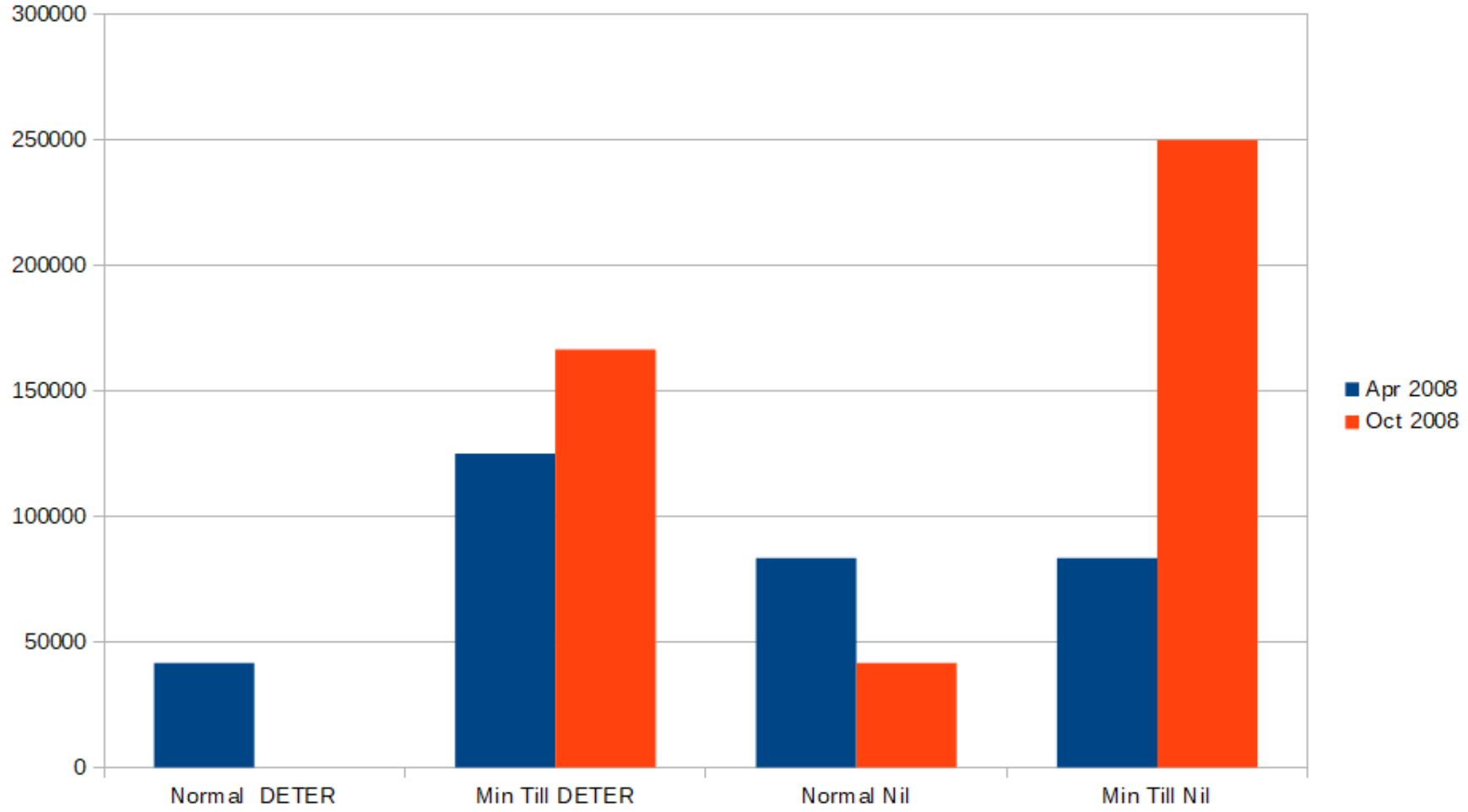
- Three members of the genus *Agriotes* are our main problem.
  - *A. lineatus*, *A. obscurus* & *A.sputator*.
- Larvae of other genera can also be found in UK soils
- Our knowledge of non-*Agriotes* species is relatively poor.
- We also have *Agrypnus, Athous, Ctenicera, Hemicrepidius* and *Melonotus* species in our soils.
- In some sites, *Agriotes* are in the minority, particulary high OM% soils

Why are problems increasing?

FACTORS AFFECTING POPULATIONS	
FEWER OF THESE	**MORE OF THESE**
Insecticides in soil (eg beet, veg, cereal ST)	Green cover autumn/winter
Cultivations after cereal harvest	Grassy habitats in farmland
Cereal seed treatments (juvenile feeding)	A warming climate (affects life cycle)
	Hectares cultivated /day (predation)
Problems seem to be increasing in Europe generally	
Four Cs: Cultivations, Cropping, Chemicals and Climate	

Why are problems increasing?

Cultivations and seed treatments- cereals



R268 Lole 2010

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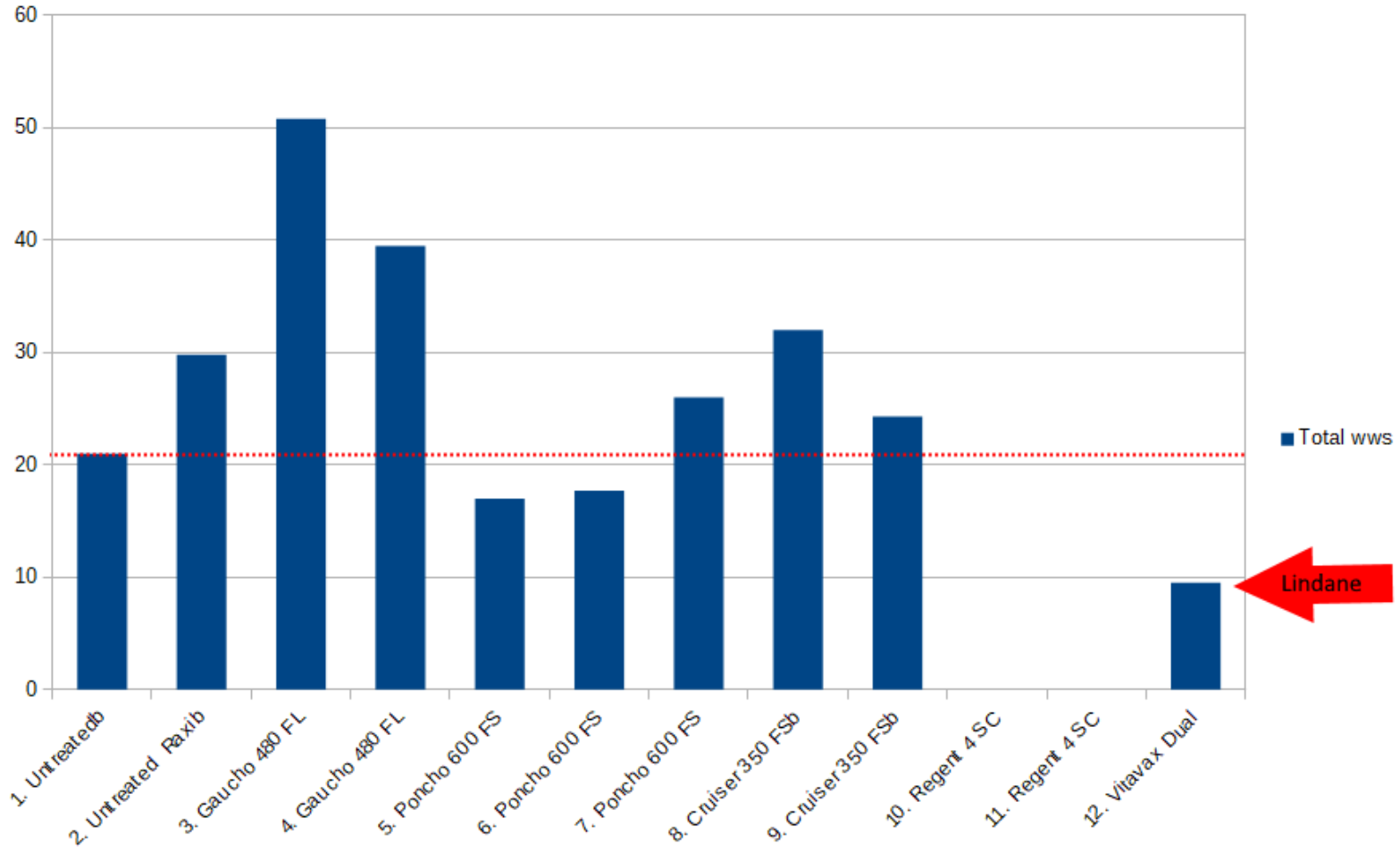
Why are problems increasing?

Cereal seed treatments would have played a vital role



Wireworm Management I: Stand Protection Versus Wireworm Mortality With Wheat Seed Treatments
ROBERT S. VERNON,1 WILLEM G. VAN HERK, MARKUS CLODIUS, AND CHANTELLE HARDING
Paciþc Agri-Food Research Centre, Agriculture and Agri-Food Canada, P.O. Box 1000, Agassiz, British Columbia, Canada V0M 1A0

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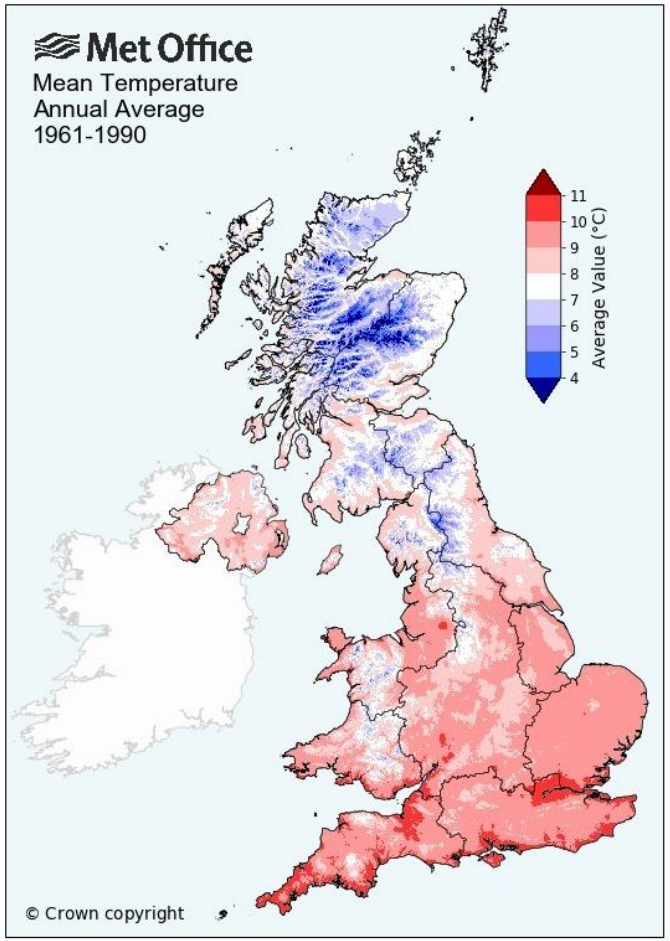
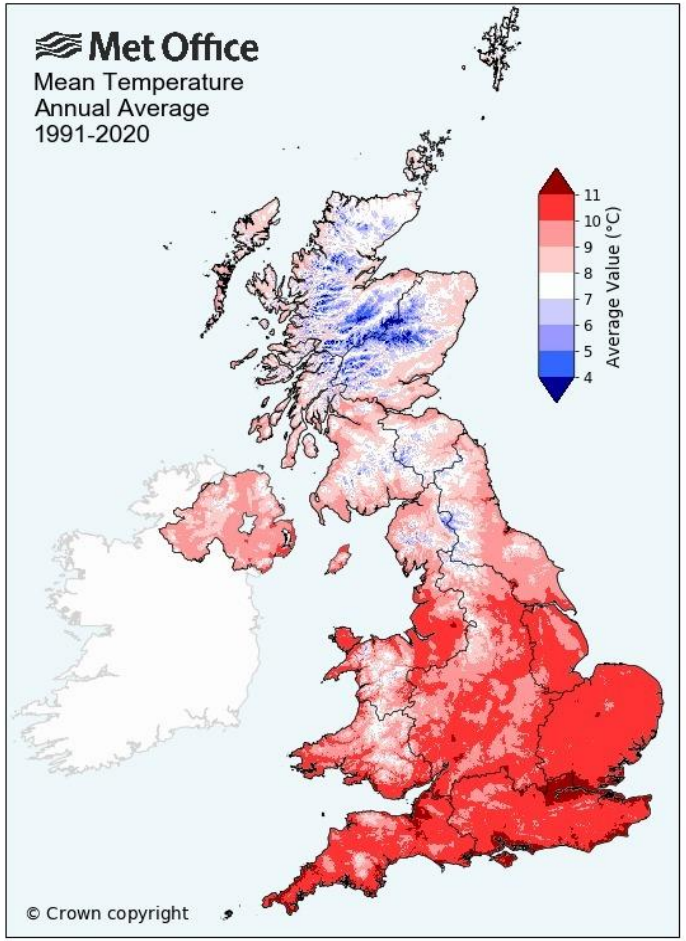
Why are problems increasing?

Our problems have always seemed to be worse in the warmer parts of UK

1961-1990



1991-2020



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Why are problems increasing?

- Larvae, 4 years?

- Swiss work, near Zurich, a similar climate to the Midlands in UK has indicated a shorter lifecycle.

Development cycle	*A. obscurus*	*A. lineatus*	*A. sputator*
3 years	47 %	58 %	61 %
4 years	35 %	17 %	28 %
5 years	18 %	25 %	11 %

Pot experiments in the field, ART Reckenholz, 2001 to 2005.

Why are problems increasing?

- We can no longer rely on control in other parts of the rotation.
- Cultivation and insecticides in cereals reduced populations.
- Carbamate insecticides in sugar beet and vegetables, killed larvae.
- Non-target control of adults and larvae was an important factor.
- In 2023, onion growers lost Tefluthrin ST, suddenly problems in onions!

IPM

- **Risk assessment is critical**
  - The soil type, rotation and landscape influences risk
  - We must look at the whole rotation
  - Not just the crops, It is what we do between those crops
  - And when we do it
  - You will not understand the problem until you look at the whole situation

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IPM:Identifying risk

- Bait trapping in UK was unreliable, we have improved it.
  - European work pointed the way, Simagrio-W
- Trapping in Autumn improves management options.
- Pre-growing module traps can be used to speed up work.
- Min temperature 8C, wheat + maize bait traps.
- Oat based traps can become mouldy, asthma!

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IPM:Identifying risk

- It is essential that people can identify what they find in bait traps.
- Produce clear guidance.
- Other soil insects often confused
- Particularly stiletto fly larvae (family Therevidae)

Checking traps

- Many other invertebrates are attracted to bait traps, not all are wireworms and some may be beneficial insects.
- The stiletto fly larvae are frequently confused with wireworms but should not be. Stiletto fly larvae are white and translucent, have no legs, and are pointed at each end.
  See image 1 for stiletto fly
- Large millipedes (image 2a) are often found, they are dark grey/black and have many legs.
- Centipedes (image 2b) are the same colour as wireworms but again have many legs.
- Carabid or rove beetle larvae also cause confusion, see image 3.

Image 1:

Image 3:

Image 2:

Hintock Kwai, 60B London Rd, Downham Market, Norfolk, PE38 9AT
M: 07980 314911 blackthornarable@gmail.com www.blackthornarable.photoshelter.com

- The major visual differences between the groups (genera) is at the tail end, for ease called the 9th abdominal segment (9AS) . Agriotes are rounded at the 9AS with two dark dots.
- All the larvae on this page are UK wireworms.

4: 9th AS of Agriotes larvae

1: Agriotes larvae

3: Athous species

2: Adrastus pallens

5: Hemicrepidius niger

Hintock Kwai, 60B London Rd, Downham Market, Norfolk, PE38 9AT
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IPM

- **Cultural control**
  - Identify where the pest is
  - Change variety
  - Change planting plans
  - Lift high risk areas early
  - Sprout crop to advance development

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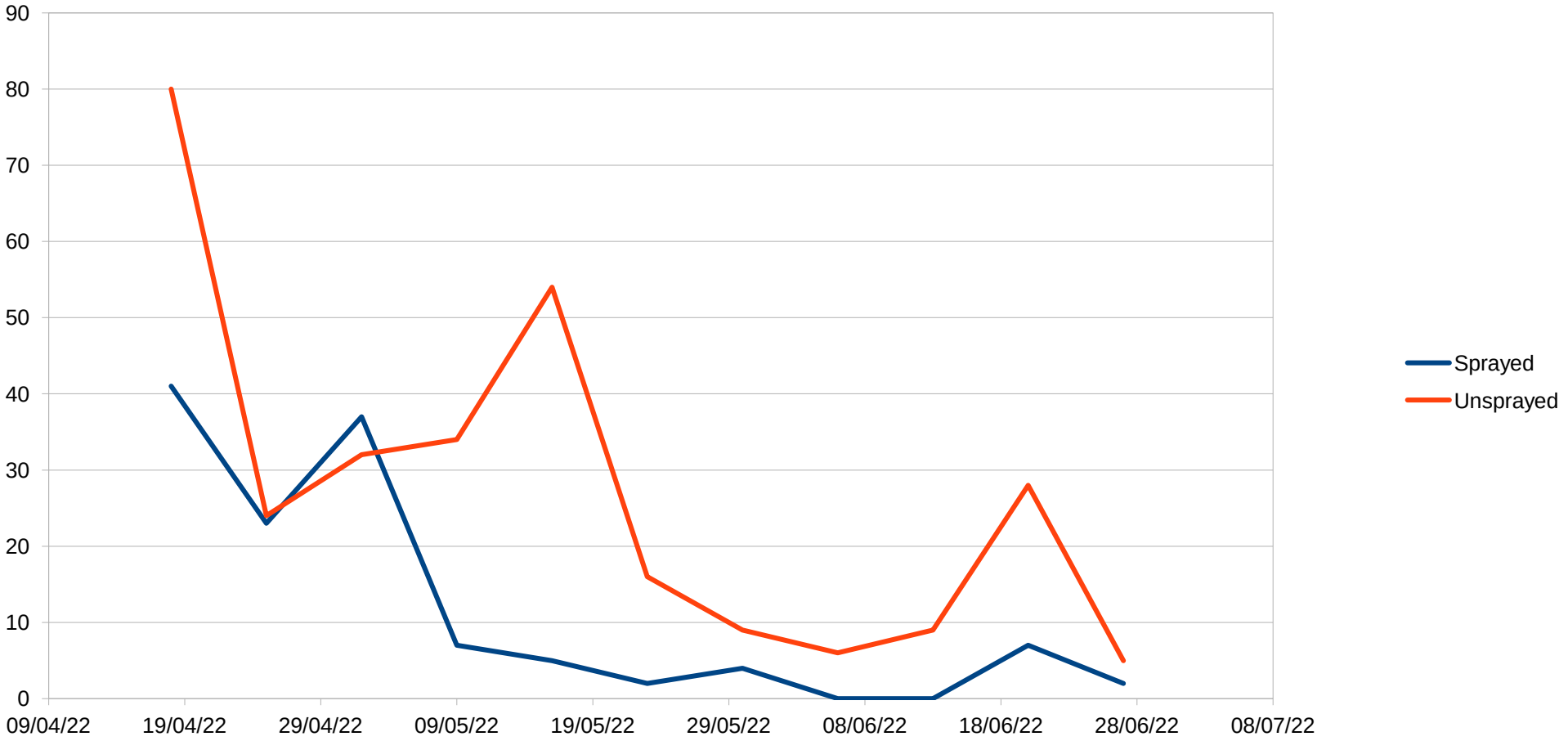
IPM:Identifying risk

- **These factors indicate a high risk for arable situations**
  - Short term grass or stewardship (2 years)
  - No autumn cultivation (Aug/Sept)
  - Some autumn green cover, often just weedy stubbles
  - Permanent grass, rivers, reservoirs nearby.
  - Usually, lots of cereals in the rotation
  - Moisture retentive soil.
  - Anything that favours egg laying and survival of young larvae.

IPM: Monitor adult activity

Pyrethroid insecticide in rotation crop, control of adult beetles



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IPM: Monitor adult activity

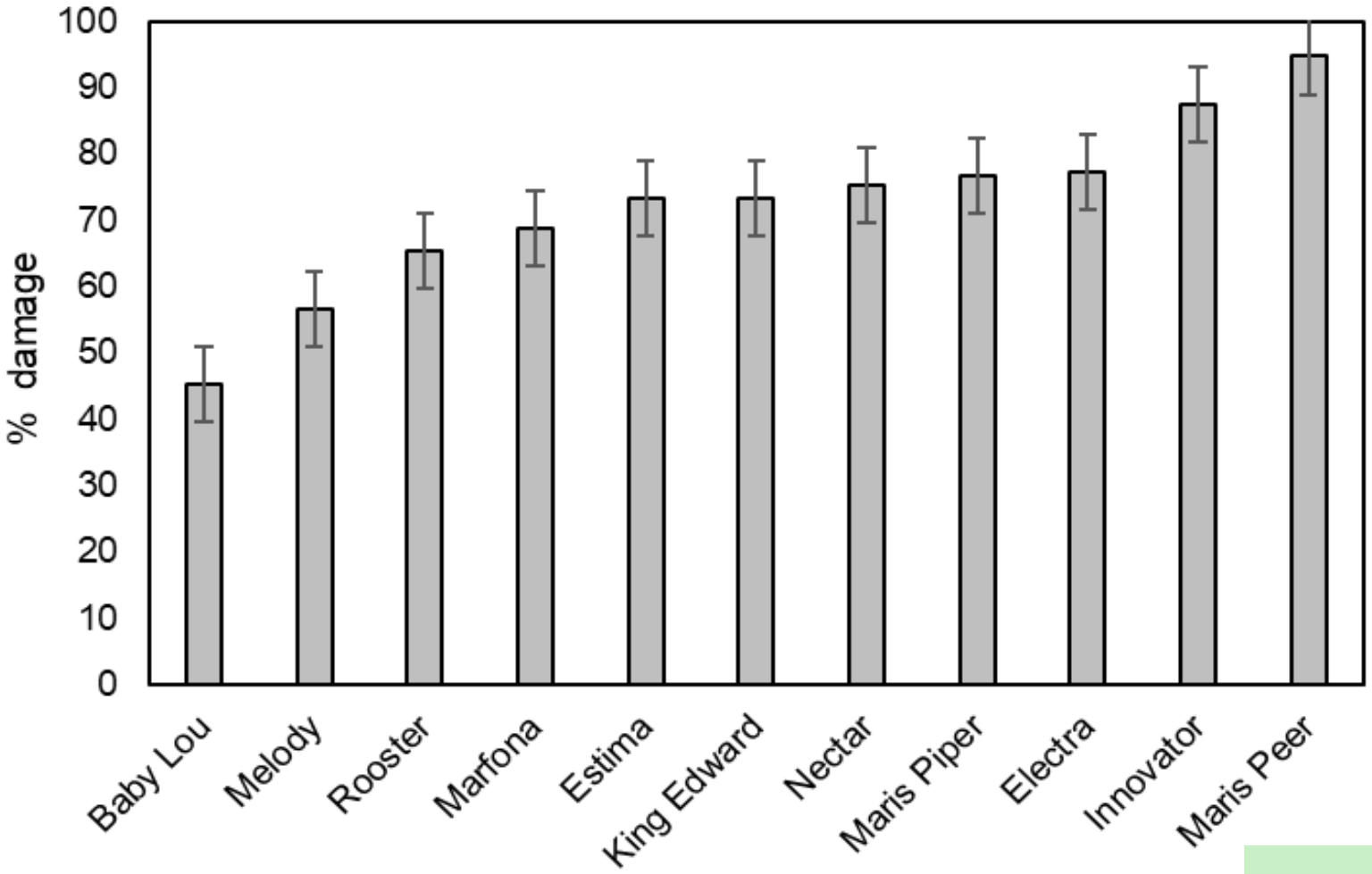
- **Monitor adult activity to enable the following:**
- Potential to disturb sensitive stages
  - When using insecticides in other crops, such as weevil in pulses.
  - Hoeing in row crops against eggs?
  - Planting date & cultivations of vining peas, maize, veg.
- Identify potential risk in 2-3 years?

Cultural control in potato crops

- Damage severity differs between potato varieties
- The best have a lower % of attack and lower severity.
- Glycoalkaloids may not be the dominant factor?
- Market tolerance is critical (processing vs fresh)
- Dual purpose varieties are safer in risky sites.
- Crop duration is also very important

Cultural control in potato crops

Damage in varieties at CUPGRA 2022



Data: CUPGRA 2022, work by NIAB

CUPGRA
Cambridge University Potato Growers Research Association

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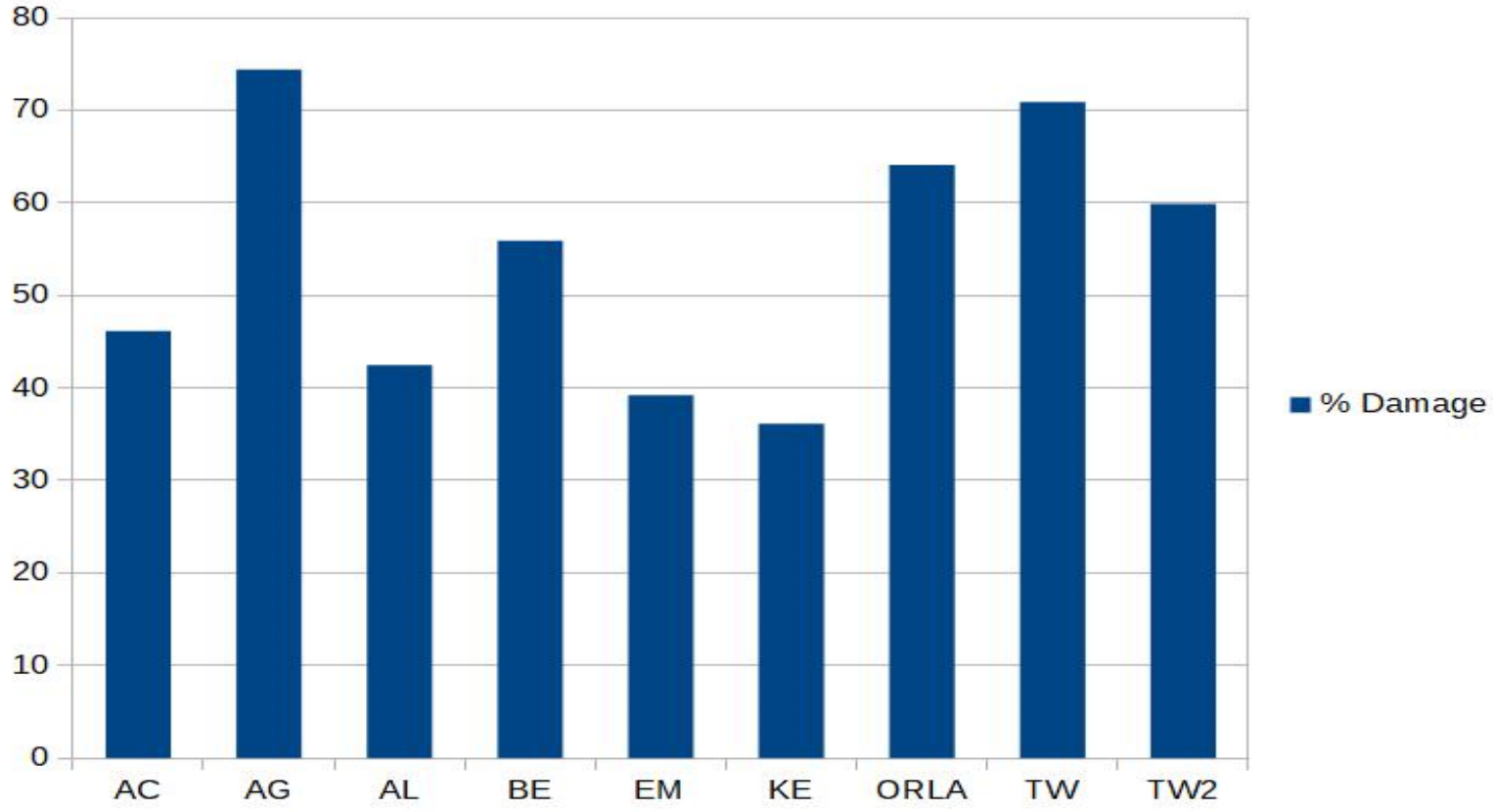
Cultural control in potato crops

Damage in blight resistant varieties / organics



Data: RB Organic / M Cox

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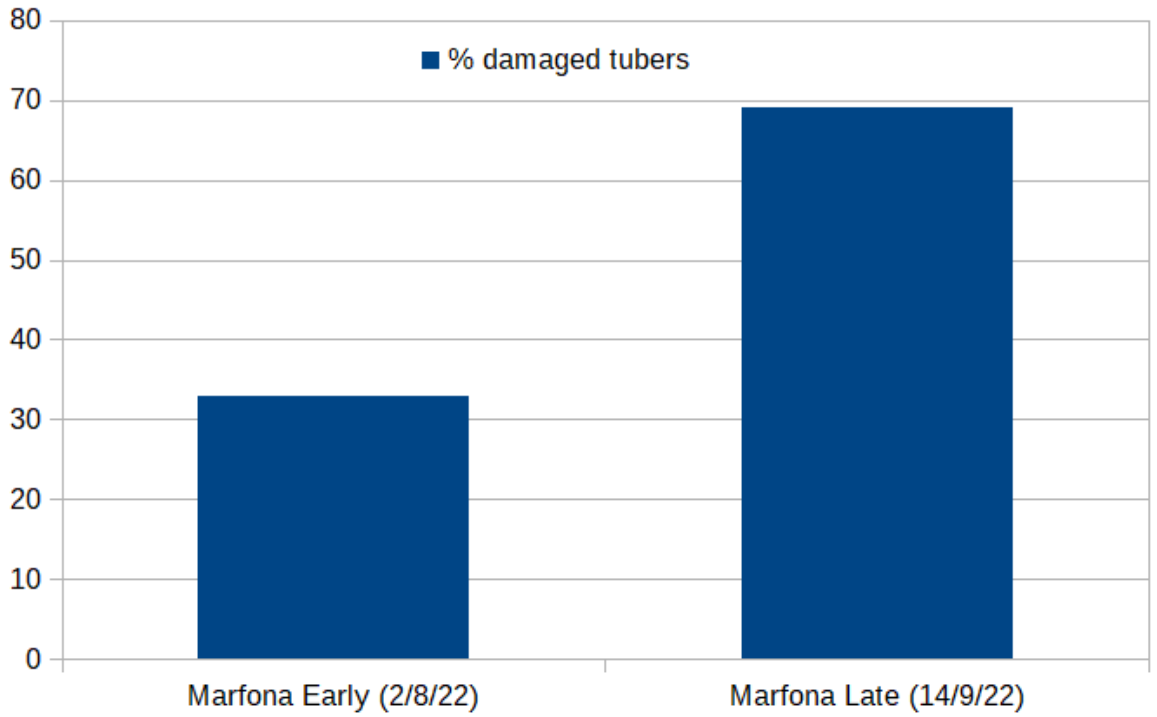
Cultural control in potato crops

Harvest date

CUPGRA work in 2022

The percentage of damaged tubers

- More than doubled in 6 weeks
- Already over 30% on 6th August



Data: CUPGRA 2022, work by NIAB

- **DAMAGE STARTS EARLY!**

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Cultural control in potato crops

Risk management

- **Identify:** Risk assessment + bait trapping
- Planting plan to reflect risk in the field, allows flexibility

Control options	
Factor	**Difference**
Variety	Damage down from 90 to 35%
Crop duration	50% reduction
Processing outlet	Much more tolerant
Insecticide	40-50%

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Knowledge transfer

- Getting the message to industry is essential
  - I give many presentations and produce guidance documents.

- Identification of the pest is critical, much confusion!

Pheromone trapping for click beetles

The traps need to be in situ before final assembly.
I use a 5 cm corer, wiggle it to fit traps tightly.
Push the trap down to ensure it is flush with the soil as shown in picture on the right.

WHERE TO PLACE THE TRAPS
Avoid crops that will be sprayed with insecticides.
Start by mid March and position traps 12-20m into the field + 10m apart. Mark well with tall canes.
Tip: Put the traps out in the order Lineatus, Obscurus, Sputator, this makes recording catches easier

Martyn Cox Blackthorn Arable Ltd 07980 314911

Checking traps

- Many other invertebrates are attracted to bait traps, not all are wireworms and some may be beneficial insects.
- The stiletto fly larvae are frequently confused with wireworms but should not be. Stiletto fly larvae are white and translucent, have no legs, and are pointed at each end.
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Image 1:


Image 3:

Image 2:

Hintock Kwai, 60B London Rd, Downham Market, Norfolk, PE38 9AT
M: 07980 314911 blackthornarable@gmail.com www.blackthornarable.photoshelter.com

Checking traps

- At the end of all this, you need to know what you have found. For a start, wireworms have 6 legs
- The major visual differences between the groups (genera) is at the tail end, for ease called the 9th abdominal segment (9AS) . Agriotes are rounded at the 9AS with two dark dots.
- All the larvae on this page are UK wireworms.


1: Agriotes larvae


2: Adrastus pallens


3: Athous species

4: 9th AS of Agriotes larvae

5: Hemicrepidius niger

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Summary

- **Improve the overall risk assessment**

  - Identify the population level (bait-trap, observe)
  - Learn about the adult activity (pheromone traps).
  - Identify damage earlier in your crops. Wash tubers.
  - Consider market tolerance & dual-purpose varieties
  - Lift earlier

Summary

Autumn management

- Create a plant free situation after a cereal crop for a month?
- Cultivation, followed by the right cover crop, inc buckwheat?…..
- Consider biofumigant for juveniles + wilts + PCN etc.
- Weedy stubbles really help juvenile survival, AVOID!
- Count down the years to the next crop

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Finit

Thank you

Martyn Cox Blackthorn Arable Ltd 07980 314911 blackthornarable@gmail.com

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NIBIO
NORSK INSTITUTT FOR BIOØKONOMI

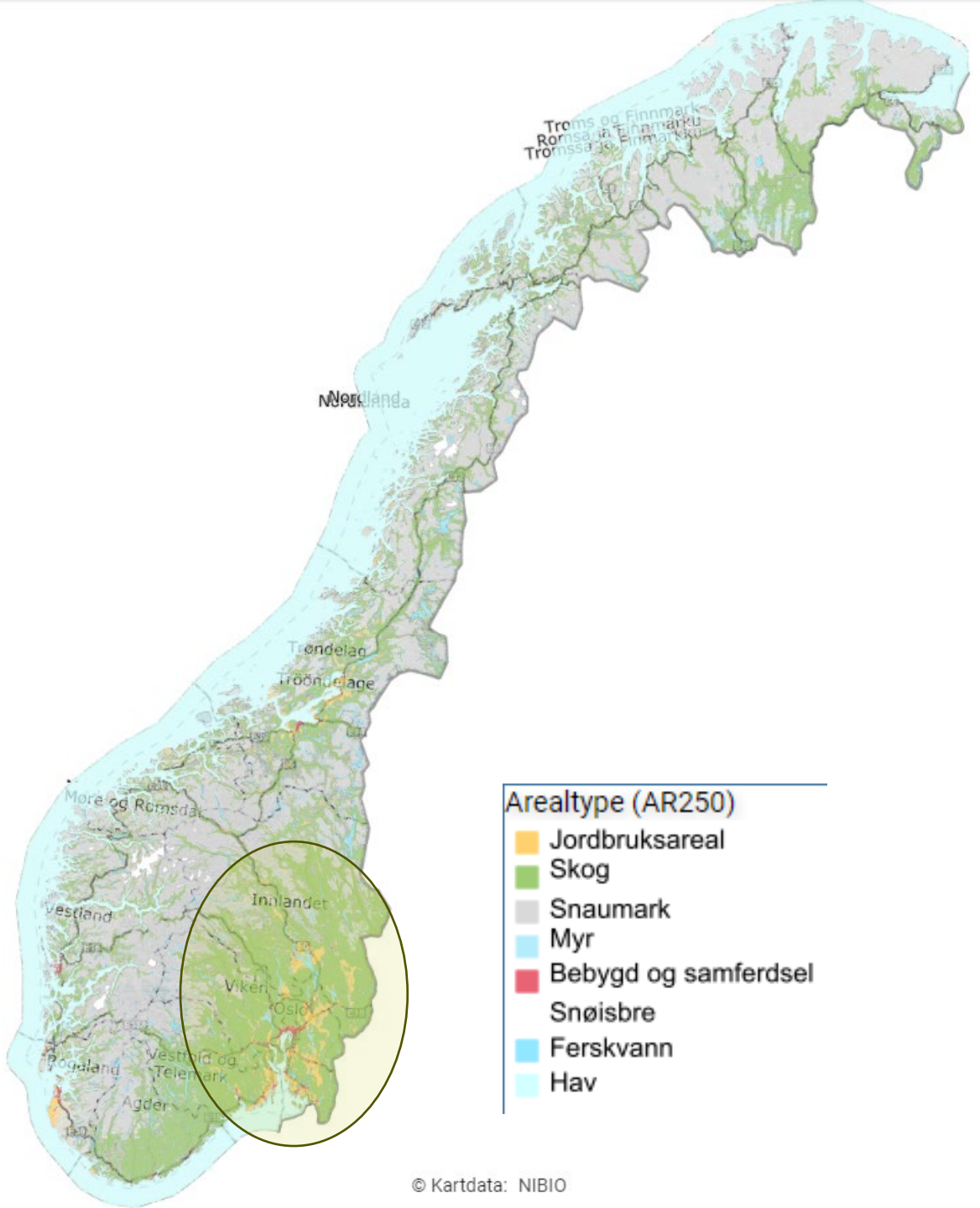
Wireworms at the northern margin of potato production in Europe - improved monitoring and pest control in Norway

Annette Folkedal Schjøll & Gunda Thöming • EAPR, Arras • 06.09.2023

Potato production in Norway

- Norway: 58°N - 71°N
- Only 3.5 % of Norway's total land area is cultivated land
- Mean field size: 1.18 ha

- Potato is the second most important cultivated plant in Norway
- Total potato production: 372 000 tons/year
- Total potato production area: 11 895 ha
- 77 % of production in south east



Wireworms on the rise in Norway…

- Many species (>60 i Norway), just a few considered agricultural pests
- Observed increasing damage to potato due to wireworms

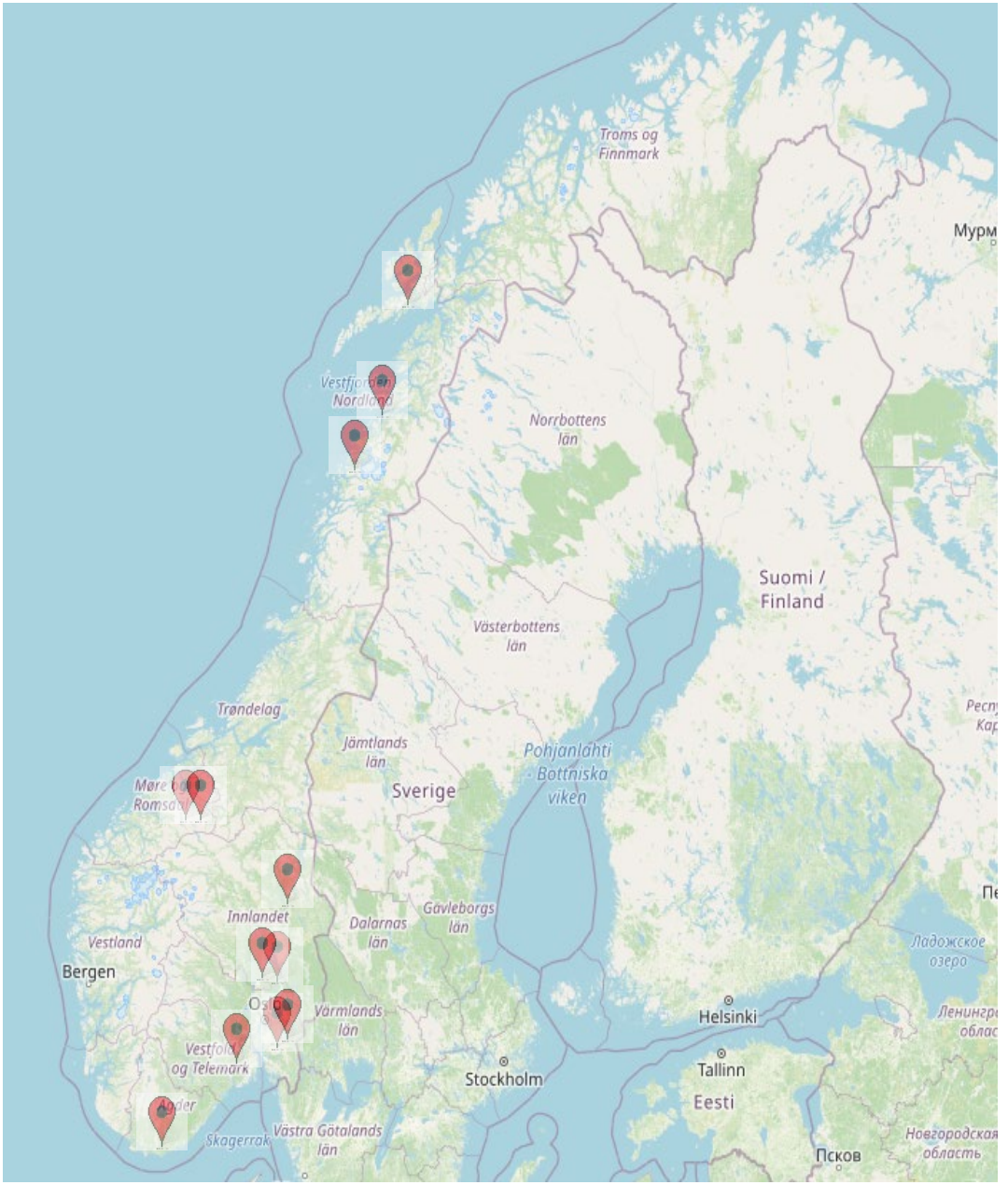
- Wireworm project , 2019-2022
  «Improved Monitoring and Control of wireworms in Norwegian potato production»
  - Species and damage caused by wireworms
  - Knowledge on potato cultivars less prone to damage
  - Crop rotation and decision support system
  - Alternative biocontrol method for direct control in field

Adult click beetles of *Agriotes obscurus*

Wireworm belonging to *Agriotes*

Survey of species 2019-2022

- Random potato fields
- Field experiments
- Bait traps
- Collected by hand
- VPT traps (acquired from AAFC, Canada)



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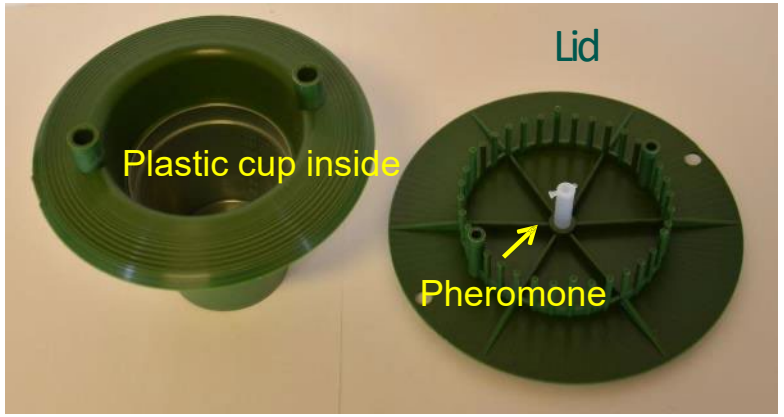
From Canada: Vernon Pitfall Trap (VPT)



- 3 different trap colours (black, brown, green)
- 1 colour specific for 1 species

- *Agriotes obscurus*
- *Agriotes lineatus*
- *Agriotes sputator*

Photos: Robert Vernon & Wim van Herk, AAFC, Canada

Photo of VPT in field: A.F. Schjøll, NIBIO
Photo of click beetles: H. Antzée-Hyllseth, NIBIO

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Bait traps to catch wireworms

Adult click beetles collected in VPT traps 2019-2020

Species, latin name	Norwegian name	Comment
Agriotes obscurus	Åkersmeller	Dominating species
Agriotes lineatus	Stripesmeller	
Agrypnus murinus	Møkksmeller	
Cidnopus aeruginosus	Mosesmeller	1 specimen (LC)
Dalopius marginatus	Sømsmeller	1 specimen (LC)
Ectinus aterrimus	Tussesmeller	1 specimen (LC)
Hemicrepidius niger	Svartsmeller	
Hypnoidus riparius	Jordsmeller	Dominating species
Selatosomus aeneus	Metallsmeller	
Selatosomus cruciatus	Korssmeller	6 specimen Norwegian Red List 2010 + 2015: NT 2021: LC

Hypnoidus riparius

Agriotes obscurus

Selatosomus aeneus

Agriotes lineatus

Selatosomus cruciatus

Agrypnus murinus

Photo: Henrik Antzée-Hyllseth, NIBIO

NIBIO

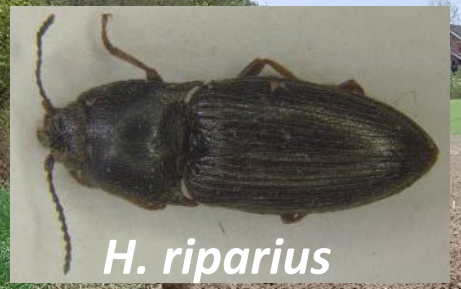

A. obscurus


H. riparius


A. obscurus

In potato field:
Hemicrepidius niger
Agriotes obscurus

In VPT traps, field margin:
Agriotes obscurus only



In VPT traps, field margin:
Hypnoidus riparius - dominating
Agriotes obscurus

In potato field:
Hemicrepidius niger
Hypnoidus riparius

No *Agriotes* larvae

Wireworms (larvae) collected 2019-2021

Species, latin name	Comment
Agriotes obscurus	Dominating species, both as adults and larvae
Agriotes lineatus	Only adult click beetle registered
Agrypnus murinus	Only adult click beetle registered
Athous haemorrhoidalis	
Cidnopus aeruginosus	
Dalopius marginatus	
Ectinus aterrimus	Only adult click beetle registered
Hemicrepidius niger	Dominating species as larvae trapped in bait traps
Hypnoidus riparius	Dominating species as adults trapped in VPTs
Selatosomus aeneus	
Selatosomus cruciatus	Only adult click beetle registered

Agriotes obscurus and *Hemicrepidius niger*

Special thanks to Dr. Jörn Lehmhus, JKI, for valuable help with wireworm ID

Photo: A.F. Schjøll, NIBIO

NIBIO

Predators…

In some locations the traps caught more staphylinid and carabid beetles than click beetles

- Healthy sign
- But we don’t want to catch them

VPT traps with/without pheromone

Ground beetle (Carabidae)

Agonum muelleri

Anchomenus dorsalis

Poecilus cupreus

Photos: Hilde Olsen, NLR Øst & Henrik Antzée-Hyllseth, NIBIO

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Canadian wireworm risk rating system

Risk of wireworm damage to a field is dependent on the fields cropping history and wireworm damage in the area

- *Years in preferred crops in the past 4 years (max 10 points)*
- *Nearest wireworm damage in the past 4 years (max 5 points)*

Wireworm risk

0-1 p (no risk)	2-3 p (low risk)	4-6 p (moderate risk)	7-10 p (high risk)	>10 p (extreme risk)
Damage unlikely	Slight damage possible, but sample for WWs to verify	Damage likely - use available WW controls	Damage very likely - avoid potatoes, or use WW controls	High damage - avoid potatoes

Controlling wireworms with ATTRACAP®

Photo: Siri Abrahamsen, NLR Viken

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ATTRACAP® - Our approach

Food for fungi and yeast

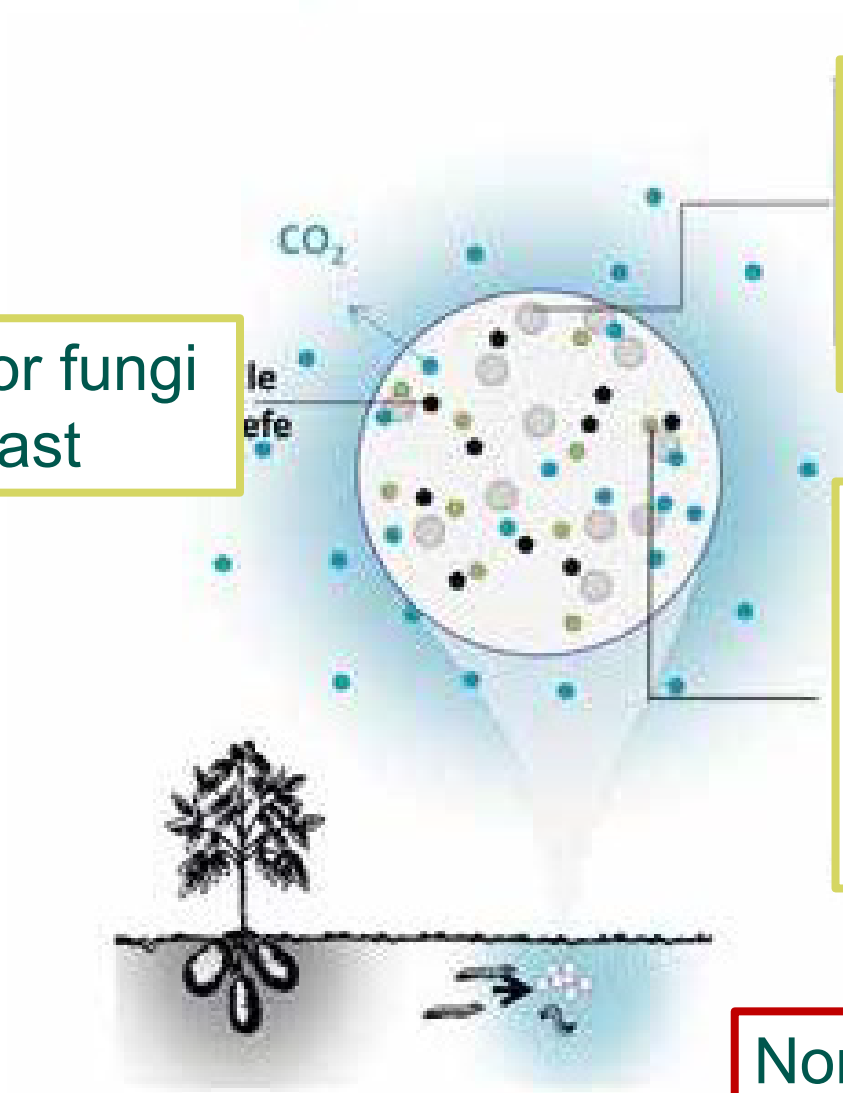


Figure: Biocare©

Yeast
CO_2 (**ATTRACT**)

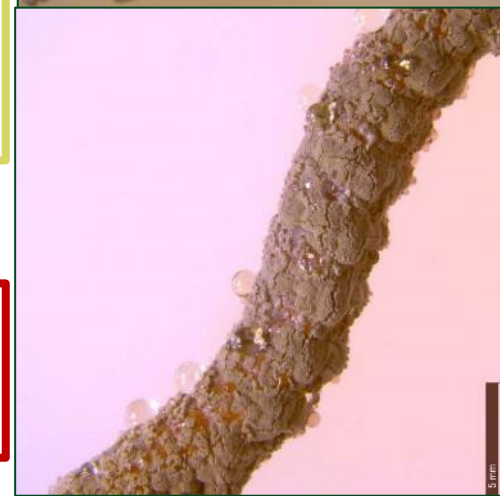
Attraction for 5 weeks

Bio-insecticid
(**KILL**)

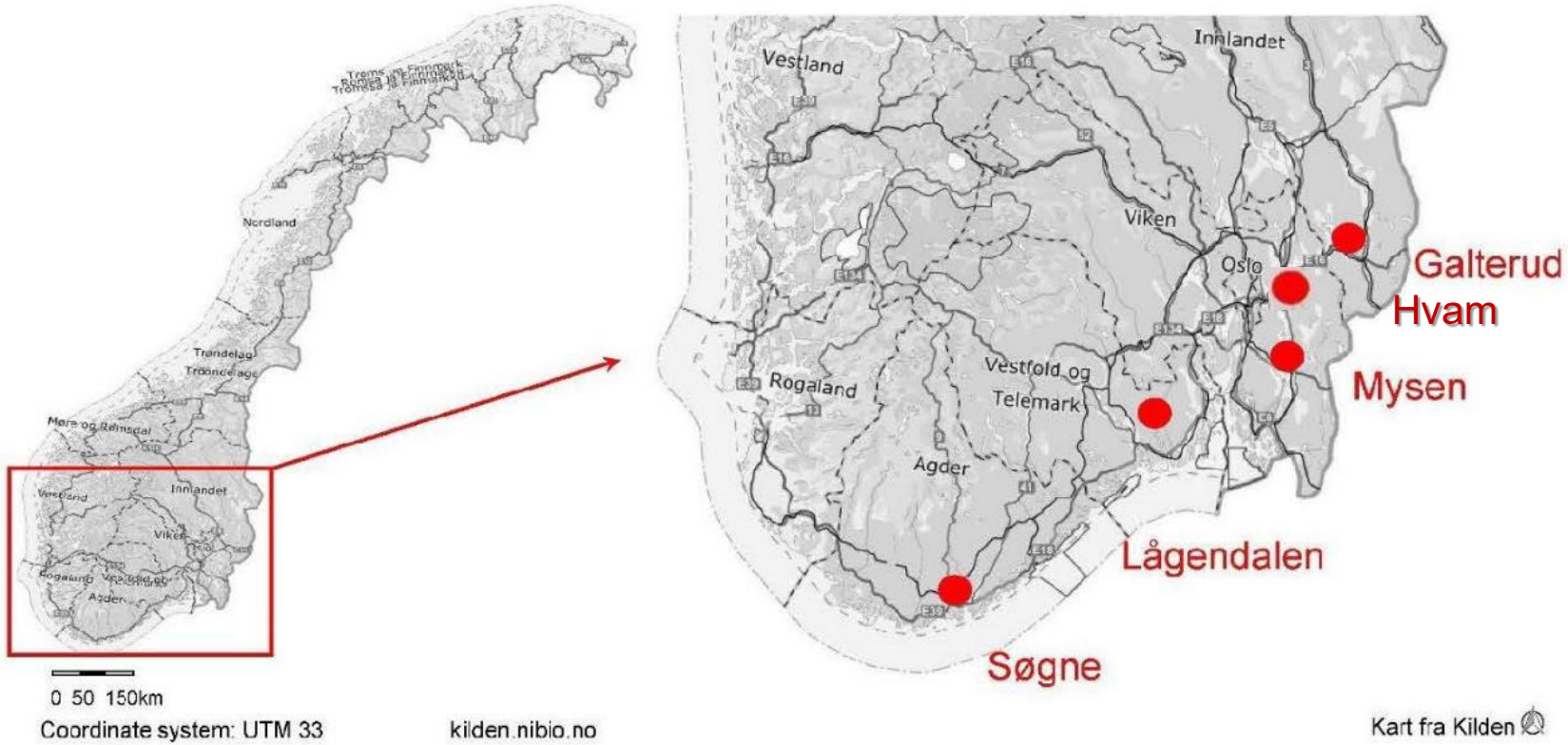
Fungi *Metarhizium brunneum*
C[illegible]III

Norwegian *M. brunneum* isolate, adapted to Norwegian conditions

Photos: M. B. Fajardo, NIBIO



Field experiments 2019-2021



- Data analyses for 4 locations only
- Low wireworm occurrence in Hvam (< 10 % damage)

	Galterud			Mysen			Lågendalen			Søgne		
	2019	2020	2021	2019	2020	2021	2019	2020	2021	2019	2020	2021
Cultivar	Fakse	Fakse	Fakse	Fakse	Fakse	Fakse	Hassel	Fakse	Fakse	Arielle	Arielle	Lady Claire
Setting date	23.05.	17.04.	05.06.	03.06.	24.04.	07.05.	25.05.	12.05.	01.06.	16.05.	16.05.	30.04.
Soil temp., setting (°C)	11.7	6.9	17.4	12.0	9.8	11.5	13.7	7.2	21.9	10.9	11.0	11.1
Soil type	clay loam			silt			clay loam			loamy sand		

Photo: E. Fløistad, NIBIO

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Field experiments 2019-2021: Wireworm damage

Damage reduction

- ATTRACAP with Norwegian isolate shows slightly better effect compared to the original ATTRACAP (significant in 2021)
- Variation among locations

Foto: E. Fløistad, NIBIO

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Factors influencing control efficiency

- Soil temperature
- Effect of soil humidity?!
- Wireworm species composition

Foto: E. Fløistad, NIBIO

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We still need more wireworm knowledge!

- Life cycles for the different pest species in Norway
- Define main factors influencing control efficiency under Norwegian conditions?
- Testing the new developments from Biocare in Norway?
  - “Fast acting” formulation
- Other crops – is it the same species involved?
- New project?

Project:
Imporoved Monitoring and Control of wireworms in Norwegian potato production

Project period: 1.3.2019 – 31.12.2022

Funding: «Forskningsmidlene for jordbruk og matindustri (FFL/JA)» the Ministry of Agriculture and Food in Norway, the Potato Industry by BAMA, Gartnerhallen SA og potato producers (tot. 7.0 mill NOK, 20% from the potato industry)

Partners: NIBIO, NMBU, BAMA, Gartnerhallen, NLR, potato producers (A. Holen, E.L-R. Lunden, J.E. Ruud)

International project participants: Dr. Robert Vernon, AAFC (Canada); Prof. Dr. Stefan Vidal, Georg-August-University (Germany); Michael Kastenbutt, Biocare GmbH (Germany); Dr. Jörn Lehmhus, Julius Kühn-Institut (JKI), (Germany)

Thank you!

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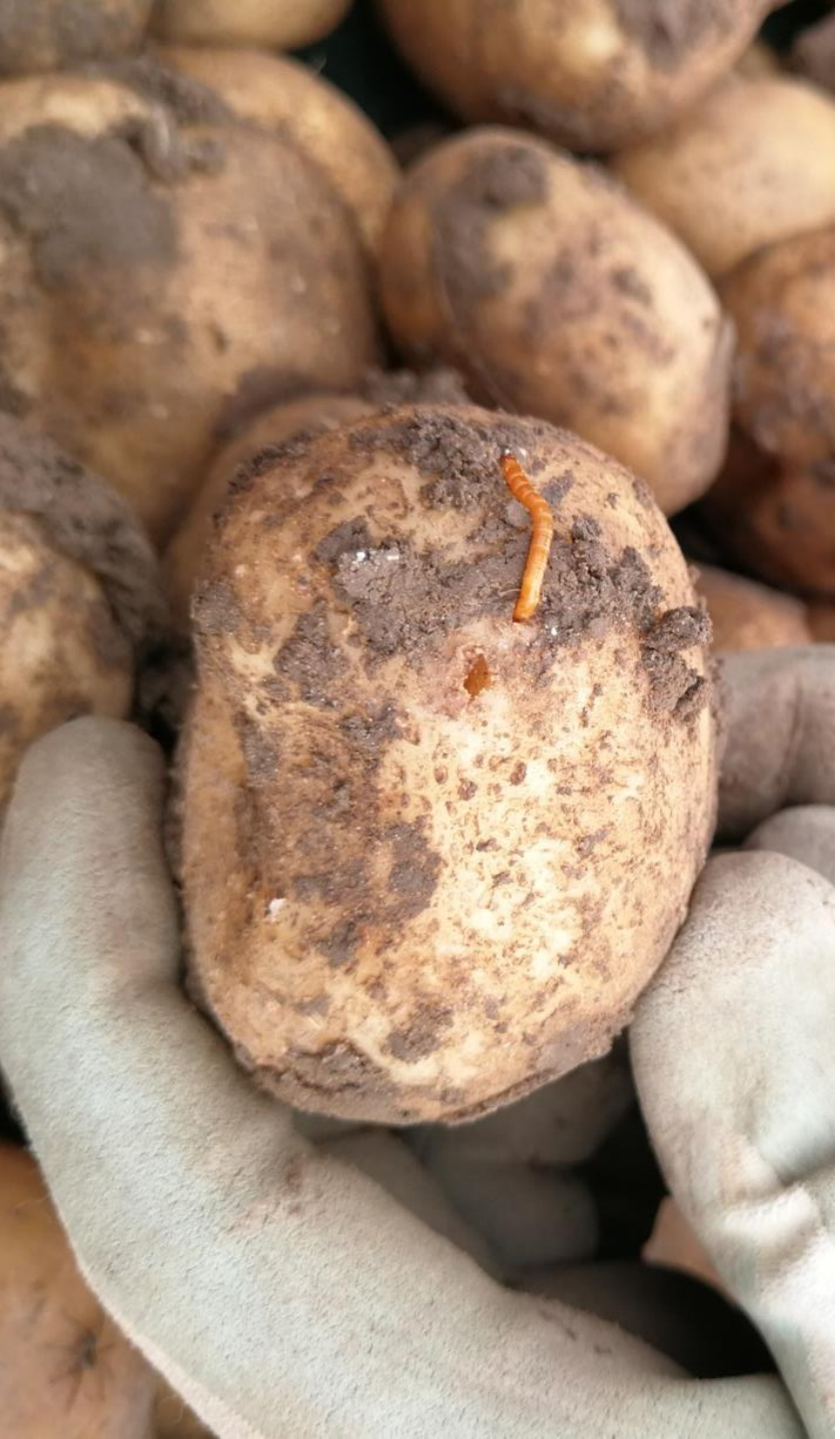

Ecobreed: Evaluating wireworm (Coleoptera: Elateridae) control strategies in potato

Eva PRAPROTNIK[1], Primož ŽIGON[1], Špela MODIC[1], Peter DOLNIČAR[2], Jaka RAZINGER[1]

[1] Plant Protection Department, Agricultural Institute of Slovenia, Ljubljana, Slovenia
[2] Crop Science Department, Agricultural Institute of Slovenia, Ljubljana, Slovenia

EAPR Pathology and Pests Section Meeting, Arras, France 2023

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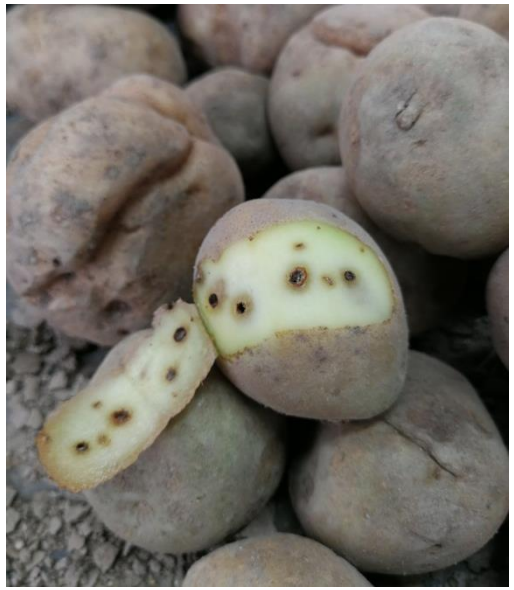
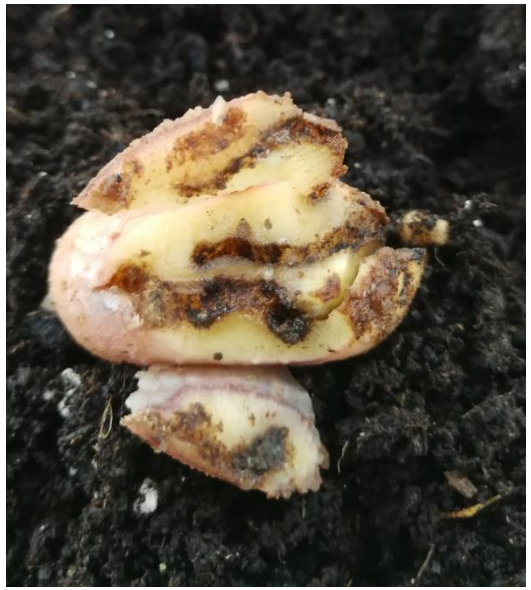
Horizon 2020
Grant agreement No 771367

Wireworms (Coleoptera: Elateridae) are one of the most important soil pests of potatoes.





They can be found in the soil where they feed on the underground parts of plants, such as the roots and tubers of potatoes.
Damage from wireworms can include wilting, stunted growth, and even plant death.

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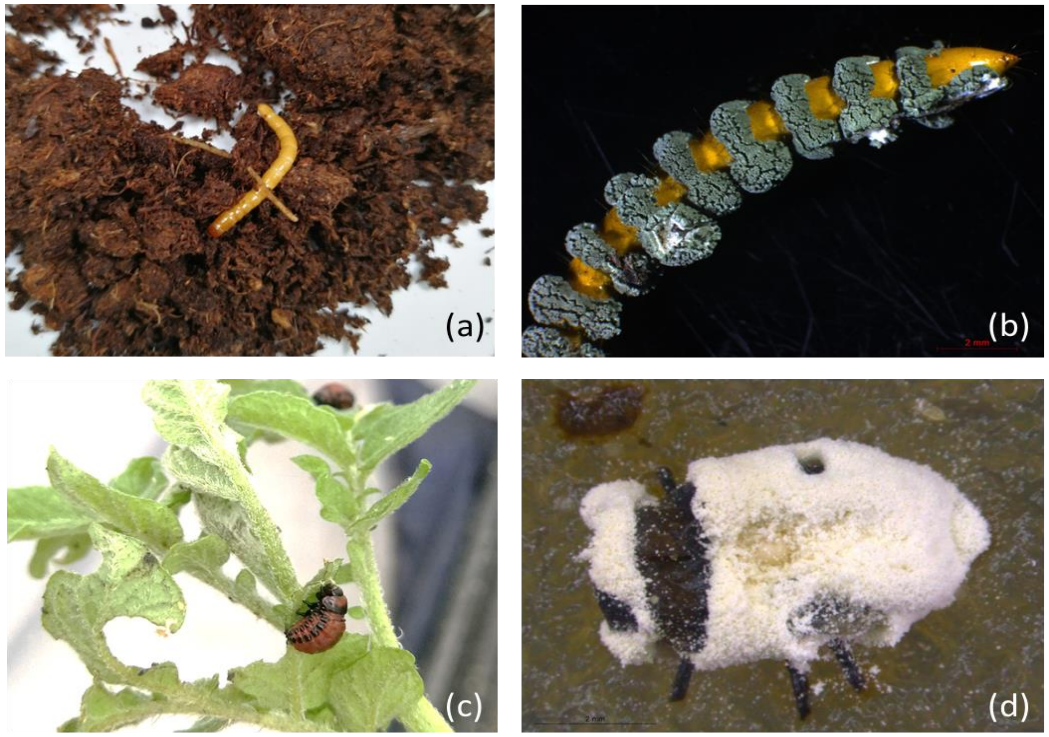
- Entomopathogenic fungi (EPF), particularly from the genus *Metarhizium* (Ascomycota: Hypocreales), have been shown to be a promising solution for wireworm control in potato
- Entomopathogenic fungi are primarily known for their ability to parasitize insects and kill or severely harm them



Spore development of entomopathogenic fungi on insects. (a) healthy wireworm; (b) wireworm infected with *Metarhizium*; (c) healthy Colorado potato beetle larva; (d) Colorado potato beetle larva infected with *Beauveria*.

Entomopathogens can also colonize the rhizosphere and plant tissues as endophytes and act as plant growth promoters. Photo: Chaudary et. al 2023

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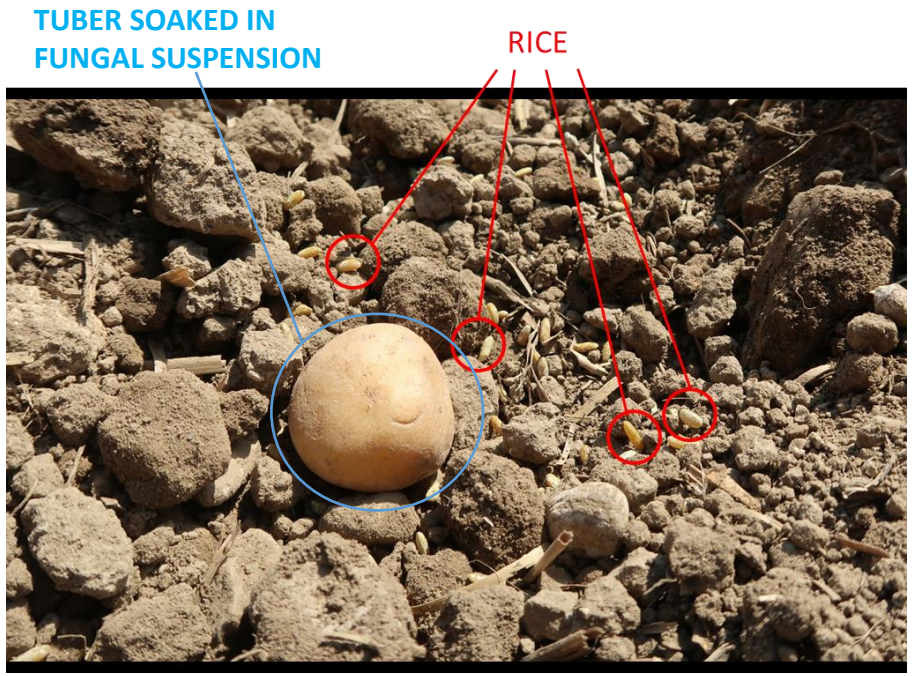
- **Aim of the study**: test different formulations based on EPF *Metarhizium brunneum* and *Metarhizium robertsii*.

- **Attracap** - biological insecticide based on EPF *Metarhizium brunneum*
  - **full dose**
  - **half dose**
- seed potato tubers were soaked in the suspension of the six highly virulent *Metarhizium* isolates from the mycological collection of the Agricultural Institute of Slovenia **(potato + fungi)**
- **(potato + rice)** fungal formulation of six *Metarhizium* isolates multiplied on rice
- **(potato + fungi + rice)** a combination of the above-mentioned fungal treatments
- **Force** - chemical insecticide conventional control
- Untreated **control**



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Set-up

Buffer zone							
4	1	2	2	6	3	5	3
1	4	1	4	5	1	2	2
5	6	3	6	4	2	1	5
3	5	4	1	2	4	3	6
2	3	5	3	1	5	6	4
6	2	6	5	3	6	4	1
Buffer zone							

Location 1

2020

Buffer zone					
4	1	2	2	6	3
1	4	1	4	5	1
5	6	3	6	4	2
3	5	4	1	2	4
2	3	5	3	1	5
6	2	6	5	3	6
Buffer zone					

Location 2

Buffer zone							
4	1	2	2	6	3	5	3
1	4	1	4	5	1	2	2
5	6	3	6	4	2	1	5
3	5	4	1	2	4	3	6
2	3	5	3	1	5	6	4
6	2	6	5	3	6	4	1
Buffer zone							

Location 3

Buffer zone							
4	1	2	2	6	3	5	3
1	4	1	4	5	1	2	2
5	6	3	6	4	2	1	5
3	5	4	1	2	4	3	6
2	3	5	3	1	5	6	4
6	2	6	5	3	6	4	1
Buffer zone							

Location 4

2021

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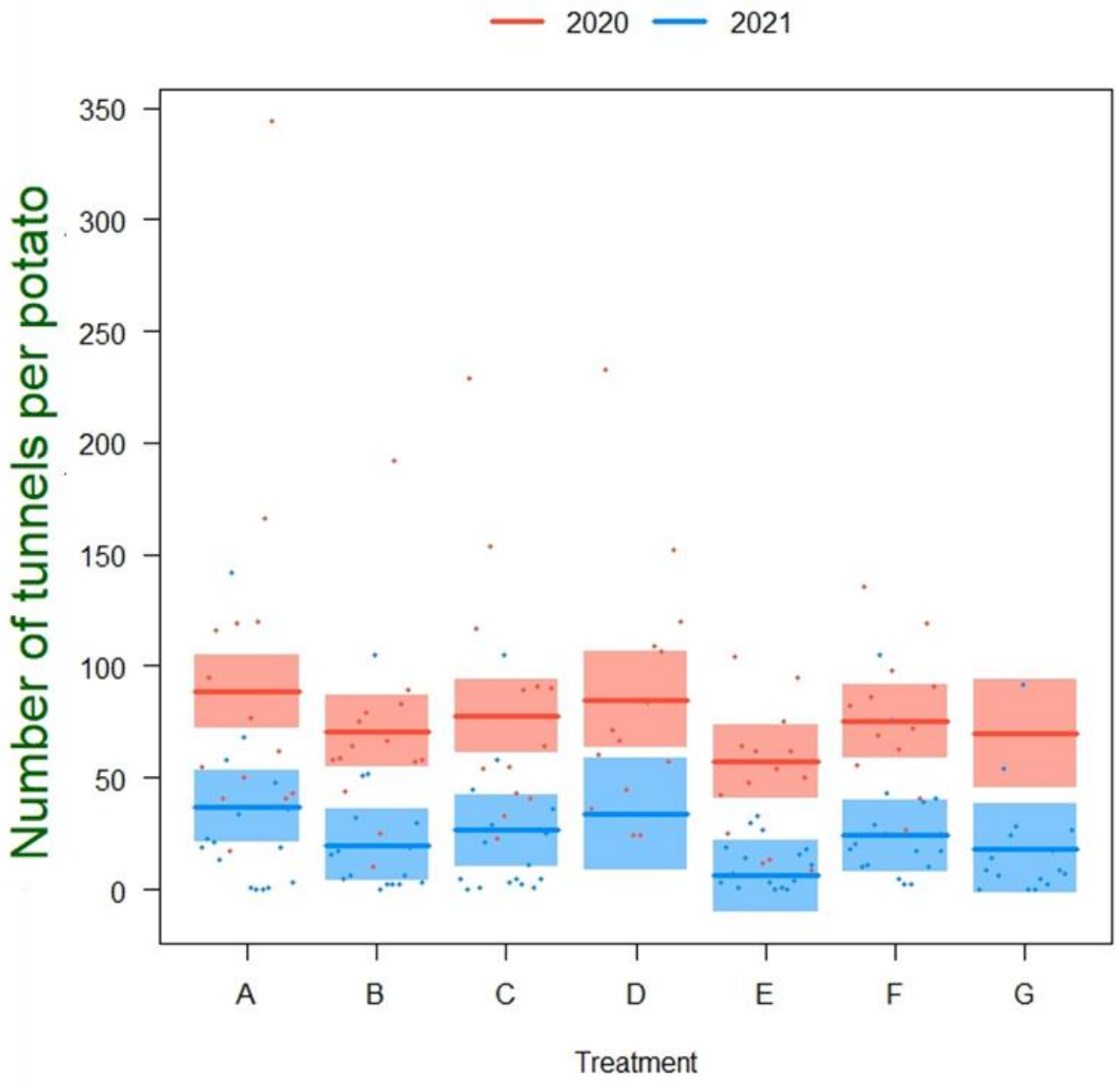

LEGEND:

A Control
B Attracap half dose
C Attracap
D Potato + fungi
E Force
F Potato + fungi +rice
G Potato + rice

Clear difference of wireworm pressure between years

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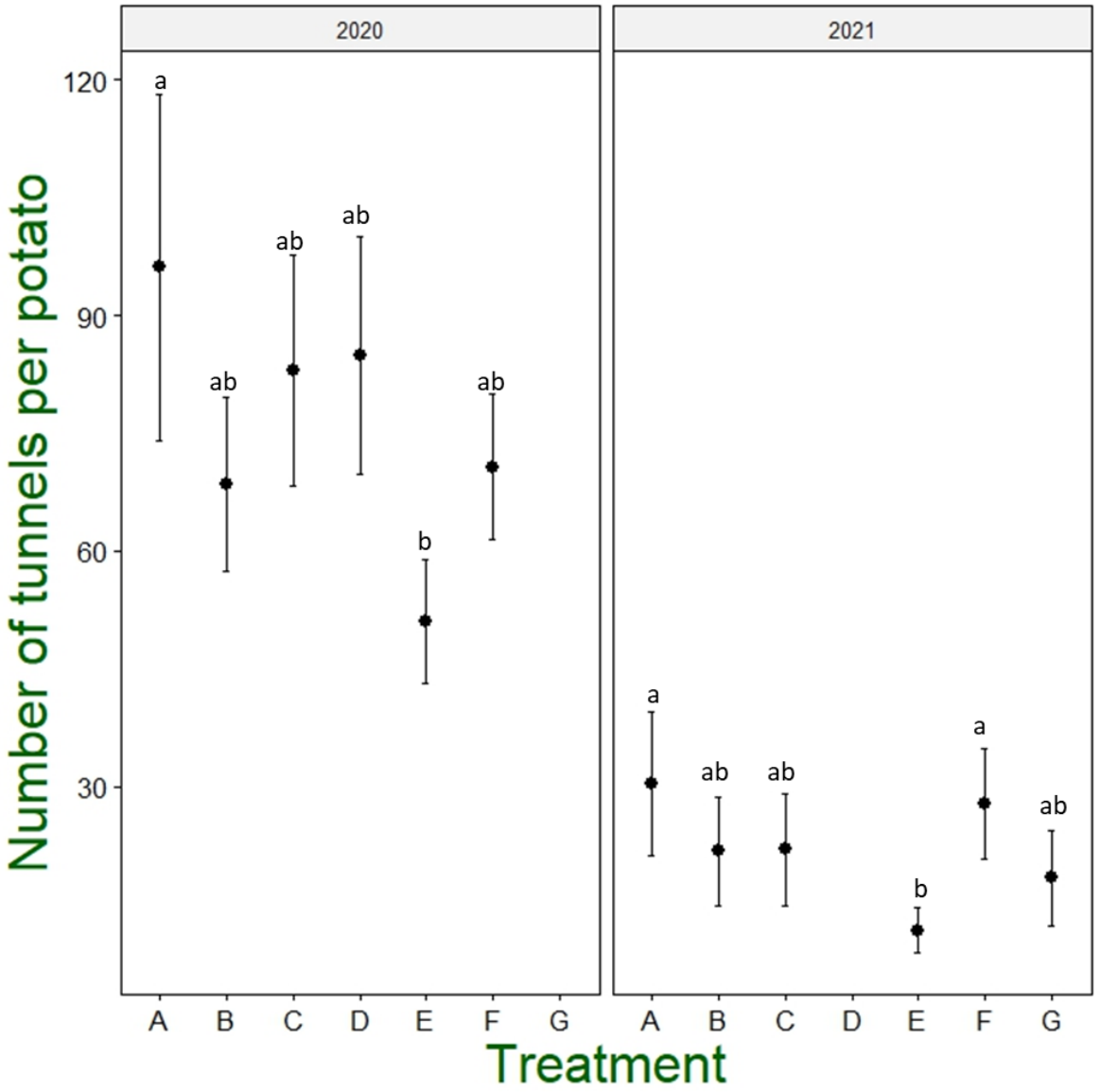

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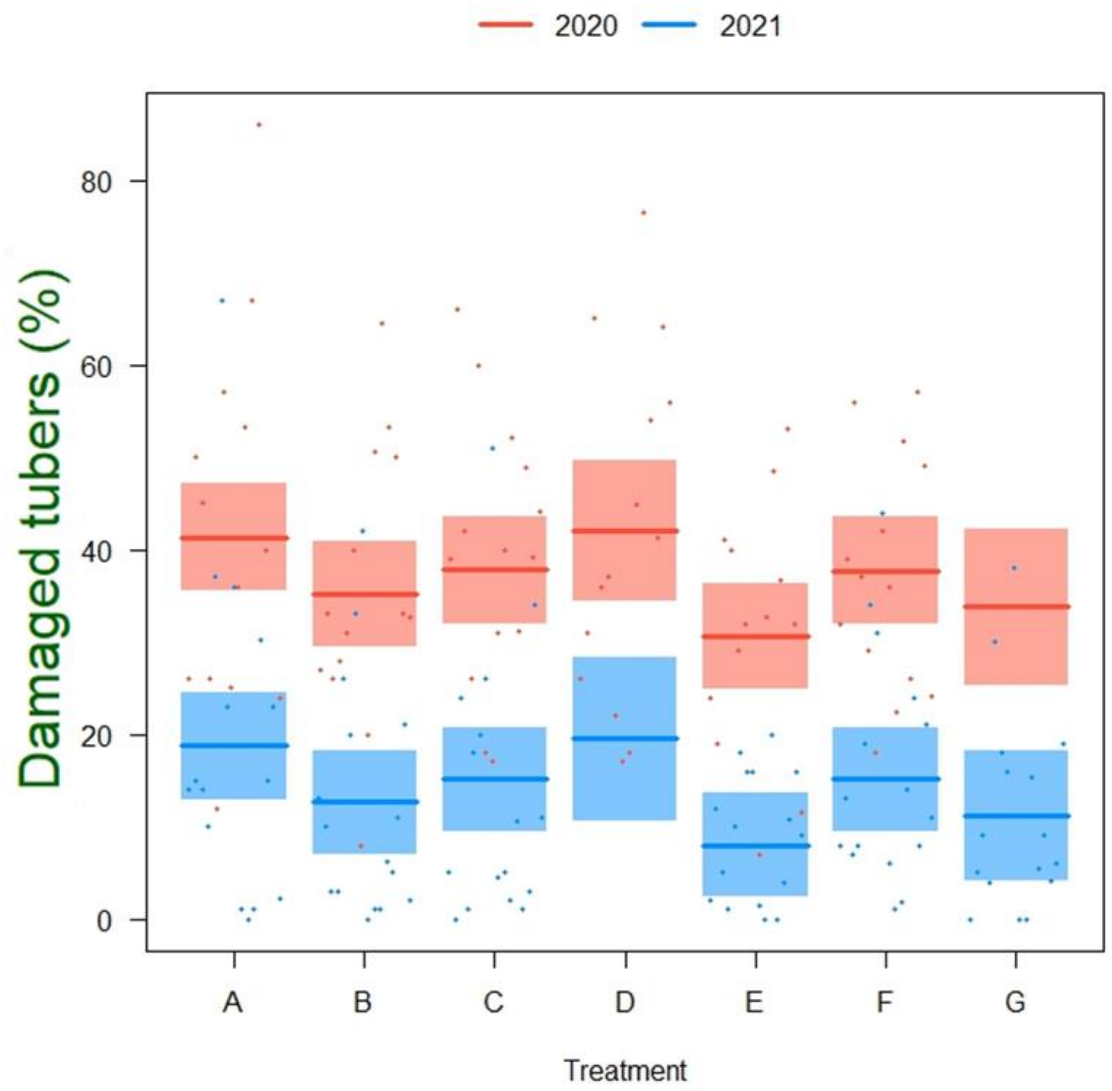

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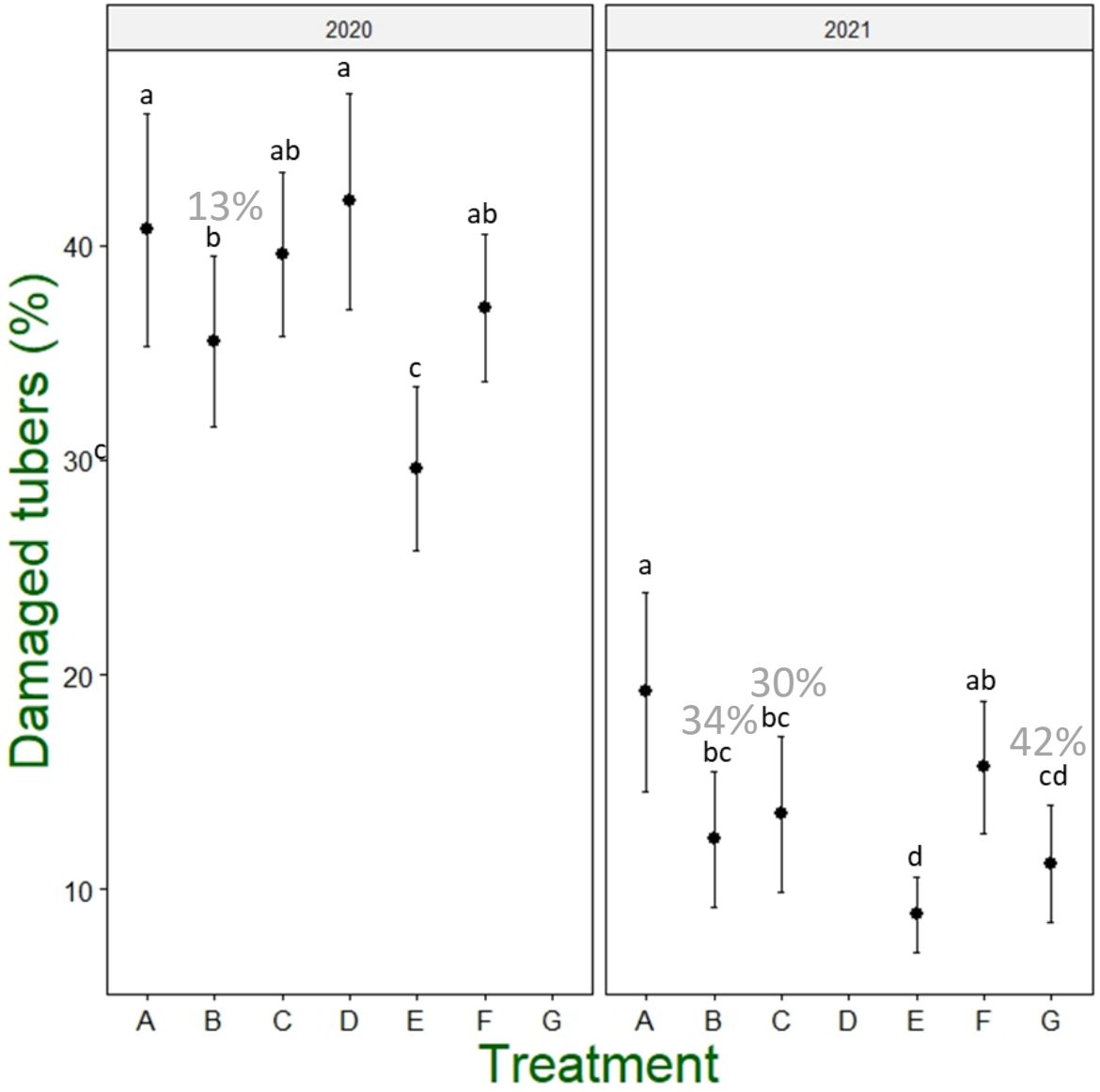

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LEGEND:
A Control
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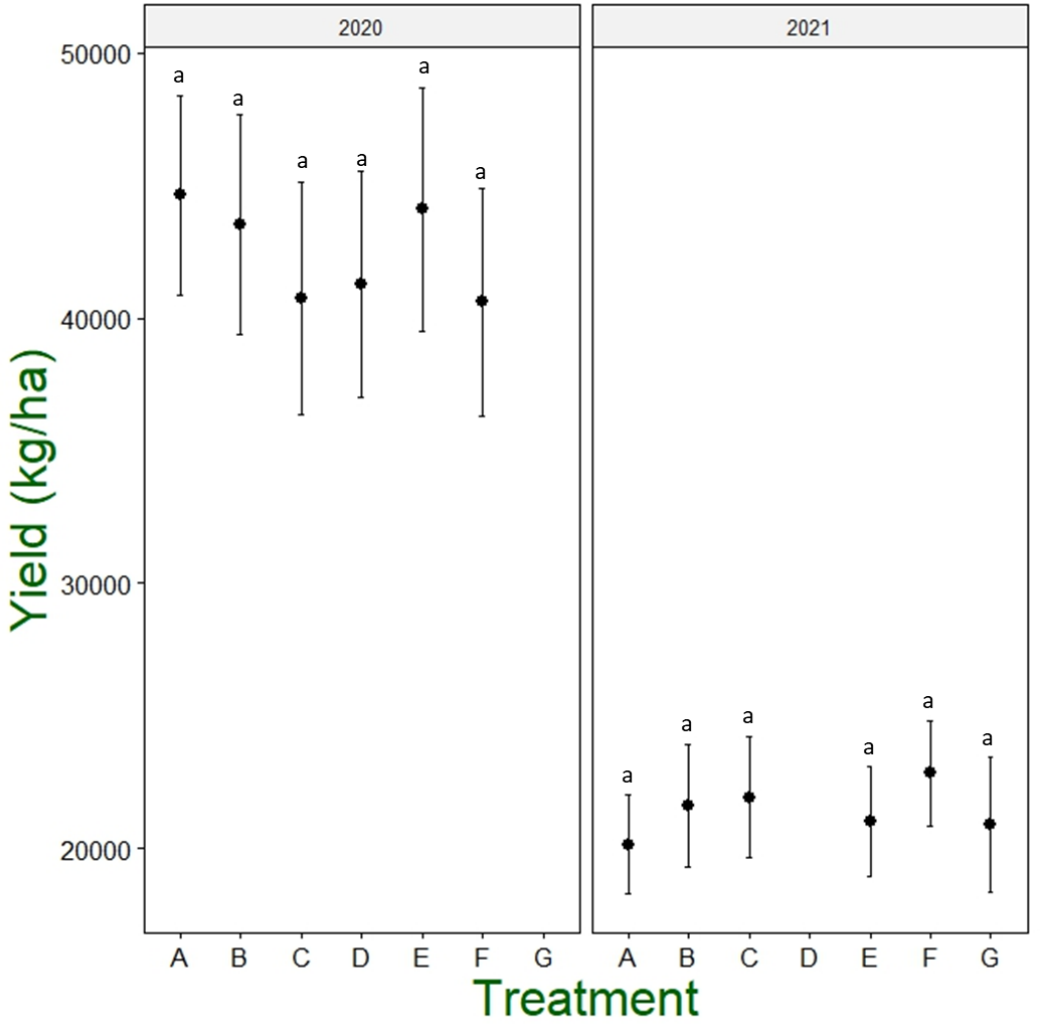
C Attracap
D Potato + fungi
E Force
F Potato + fungi +rice
G Potato + rice

Net tuber yield showed no significant differences between treatments



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CONCLUSIONS

- Bioinsecticides based on entomopathogenic fungi were not so effective in reducing the number of tunnels per potato tuber, but were more efficient at reducing % of damaged tubers
- efficacy of **fungi formulated on rice (potato + rice)** may be comparable to commercial bioinsecticides and chemical insecticides
  - reducing % of damaged tubers for 42 %
- Potato tubers soaked in fungal suspension showed to be the least effective in reducing wireworm damage

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Thank you for your attention

Consortium

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Agricultural Institute of Slovenia

BOKU
University of Natural Resources and Applied Life Sciences, Vienna

Newcastle University
UK | Malaysia | Singapore

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Distribution and flight activity of wireworms (*Agriotes* sp.) in Austria

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Mit Unterstützung von Bund, Ländern und Europäischer Union
Bundesministerium Land- und Forstwirtschaft, Regionen und Wasserwirtschaft
LE 14-20

Introduction

- In Austria, wireworms are one of the key problems in the production of potatoes, reducing the marketable yield of edible potatoes by 10 % in average per year
- The year 2018 showed an all-time wireworm damage peak in Eastern Austria with an estimated loss of about 25 % of the harvested potatoes
- Also in the maize production wireworm damages are increasing, apart from click beetle species. The pesticide-free regulation of wireworms needs an improved timing of control measures

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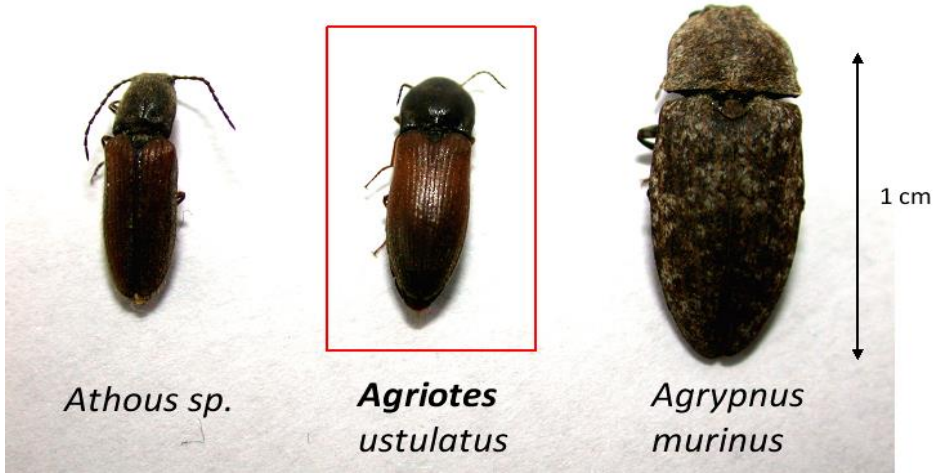
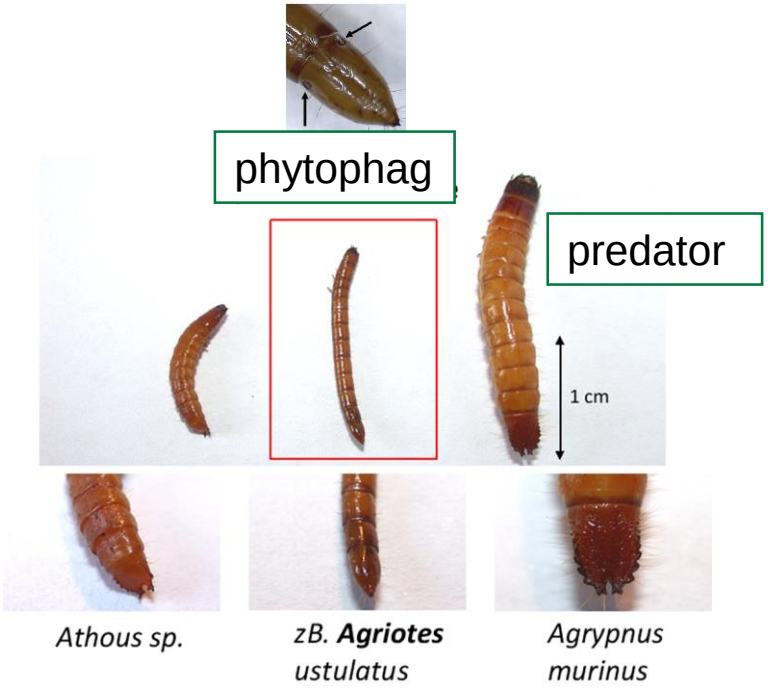
Europäischer Landwirtschaftsfonds für die Entwicklung des ländlichen Raums: Hier investiert Europa in die ländlichen Gebiete.

Click beetle / wireworm

- Wireworms are soil-living larvae of click beetles (Fam. *Elateridae*)
- The species of the genus *Agriotes* are mainly responsible for damages in Europe
- The beetles do not cause any damage



- Examples of click beetle genera



- Wireworms (larvae of click beetles)

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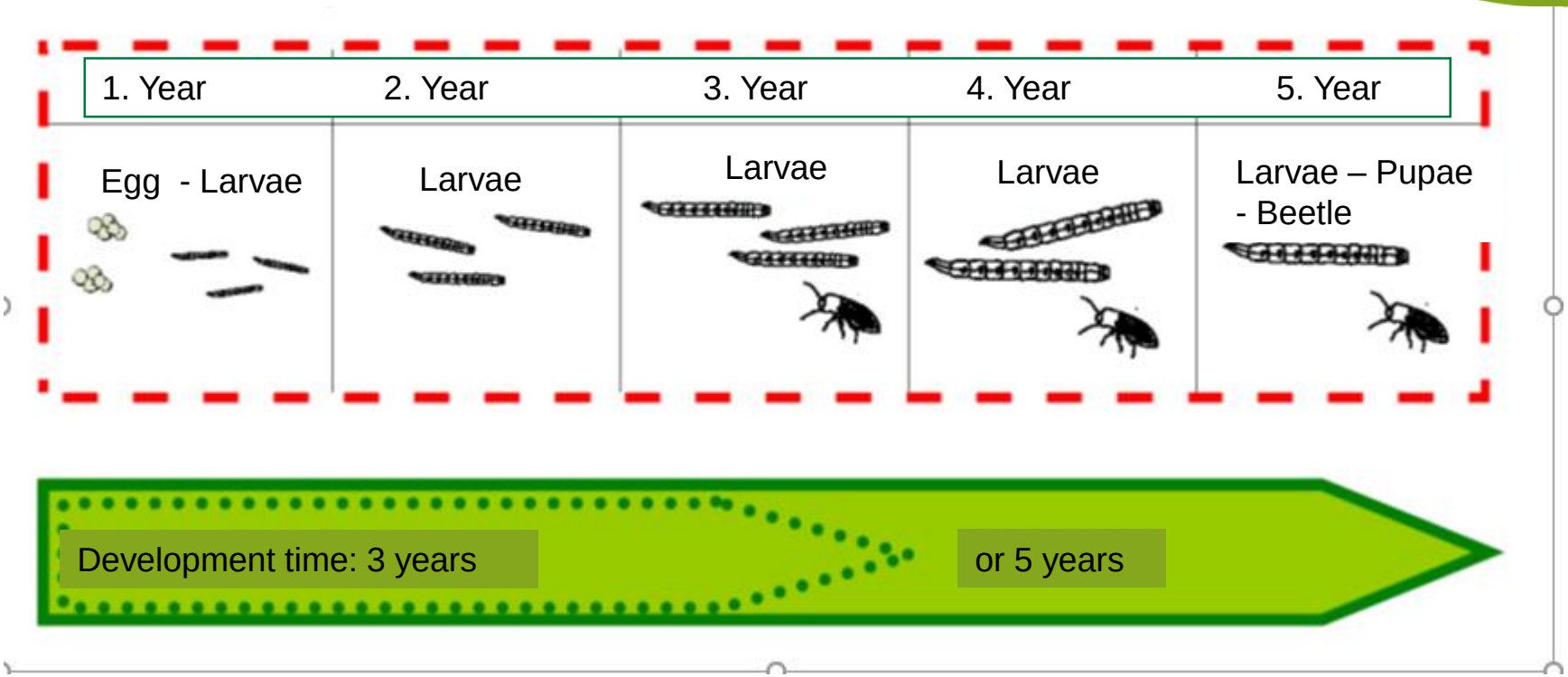
Development cycle of *Agriotes sp.*



Quelle: Schepl & Paffrath 2010

Larvae need up to 5 years (depending on species and weather) from egg to beetle

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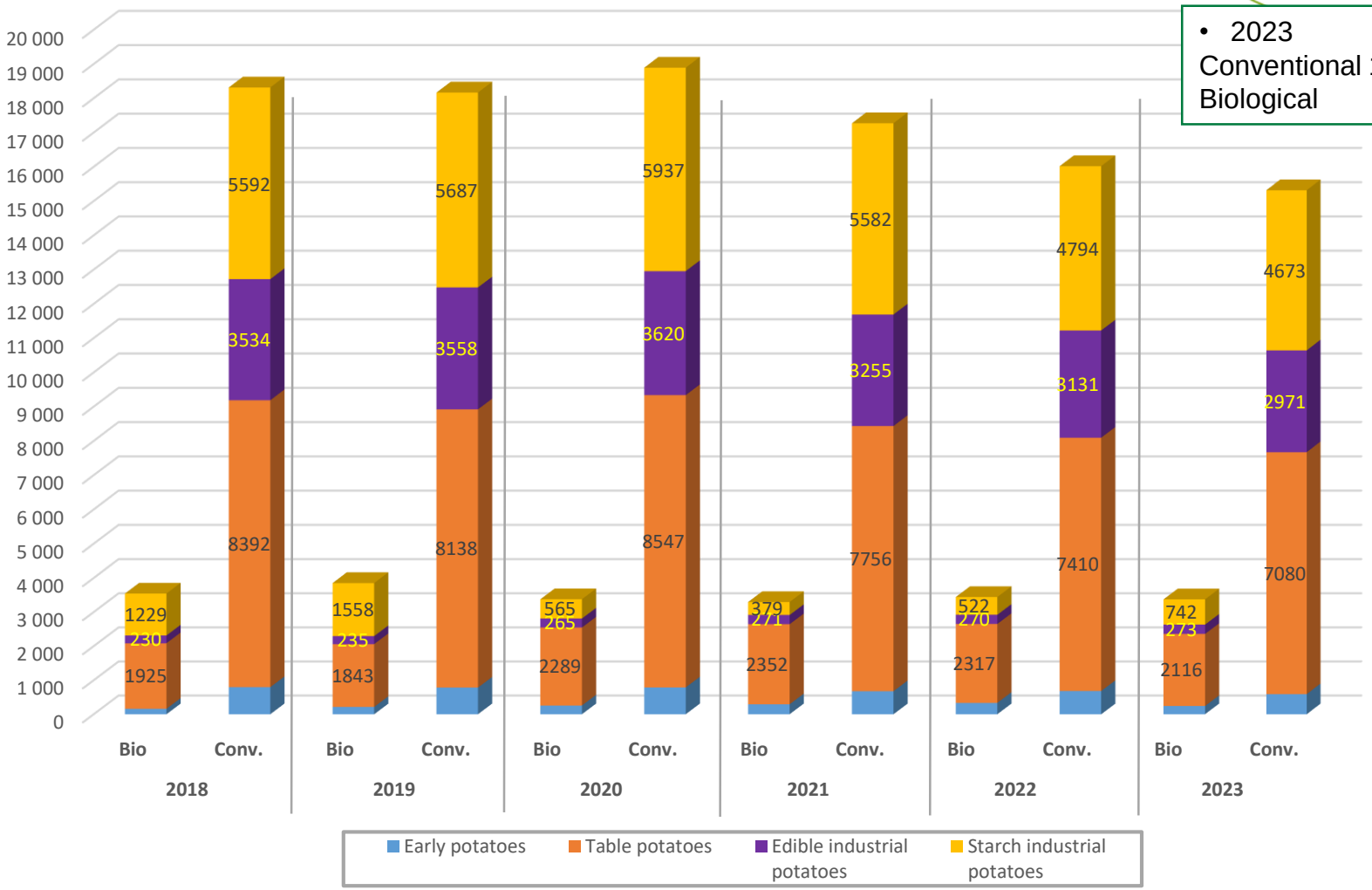
Potato acreage (ha) in Austria since 2018



- 2023
Conventional 15.314 ha
Biological 3.373 ha

Data source: Statistic Austria 2023

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LE 14-20

Austrian alert service for plant protection, monitoring *Agriotes sp*.

warndienst.at

Monitorings

Mehltau
Gelbrost
Braunrost
Septoria notorum
Septoria tritici
Microdochium nivale (Schneeschimmel)
Drechslere tritici-repentis (DTR) und der Schädlinge
Halmbruch
Septoria nodorum, S. tritici
Viruskrankheiten: BYVD, CYDV, WDV, BDV

Krautfäule
Alternaria sp.
Drahtwürmer (ELATMON Projekt)
Agriotes brevis
Agriotes lineatus/proximus
Agriotes obscurus
Agriotes sordidus/rufipalpis
Agriotes sputator
Agriotes ustulatus

Gefleckter Kohltriebrüssler
Rapsstängelrüssler
Rapsglanzkäfer
Kohlschotenrüssler
Kohlschotenmücke
Erdfloh
Zuckerrübe (ZUCKMON Projekt)
Schwarzee Bohnenblattläuse
Grüne Pfirsichblattläuse
Erdfloh
Rüssler
Cercopsora beticola
Echter Mehltau
Rost

Maiszünsler
Maiswurzelbohrer
Deoxynivalenol
Zearalenon
Fumonisine
Aflatoxine
Grüne Reiswanze
Grüner Erbsenblattlaus
Schwarze – Bohnenlaus
Nanovirennachweis
Baumwollkapselwurm
Kohlfliege
Knoblauchgallmilbe
Apfelblütenstecher
Apfelsägewespe
Apfelwickler
Kleiner Fruchtwickler
Bräunlicher Obstbaumwickler
Fruchtschalenwickler
Pflaumensägewespe
Pflaumenwickler
Pfirsichwickler
Kirschfruchtfliege
Walnussfruchtfliege
Falscher Mehltau
Amerikanische Rebzikade
Kirschessigfliege
Traubenwickler
Varroa-Milbe

Forcasting model

Acker
Septoria tritici
Septoria nodorum
Braunrost
Drechslera-tritici-repentis – DTR
Gelbrost
Zwergrost
Echter Mehltau
Netzflecken
Ramularia
Rhynchosporium
Halmbruch

Ph. infestans

Rapsstängelrüssler
Kohltriebrüssler
Rapsglanzkäfer
Kohlschotenrüssler
Kohlschotenmücke
Rapserdfloh
Obst (inkl. T-Sum)
Apfel-, Pflaumen-, Pfirsich- und kleiner Fruchtwickler
Birnblattsauger
Mehlige Apfelblatt-, und Apfelgraslaus
Obstbaumspinnmilbe
Pfennigminiermotte
Apfelsägewespe
Apfelschorf
Feuerbrand
Obstbaumkrebs
Apfelwickler
Wein
Falscher Mehltau
Echter Mehltau
Schwarzfäule
Schwarzholz
Phänologie
Biene
Varro-Milbe

Monitoring of *Agriotes sp*. since 2019
Monitoring of *Ph. infestans* und *Alternaria sp.* since 2017
Forecasting model for *Ph. infestans* since 2016 (ISIP/ZEPP)

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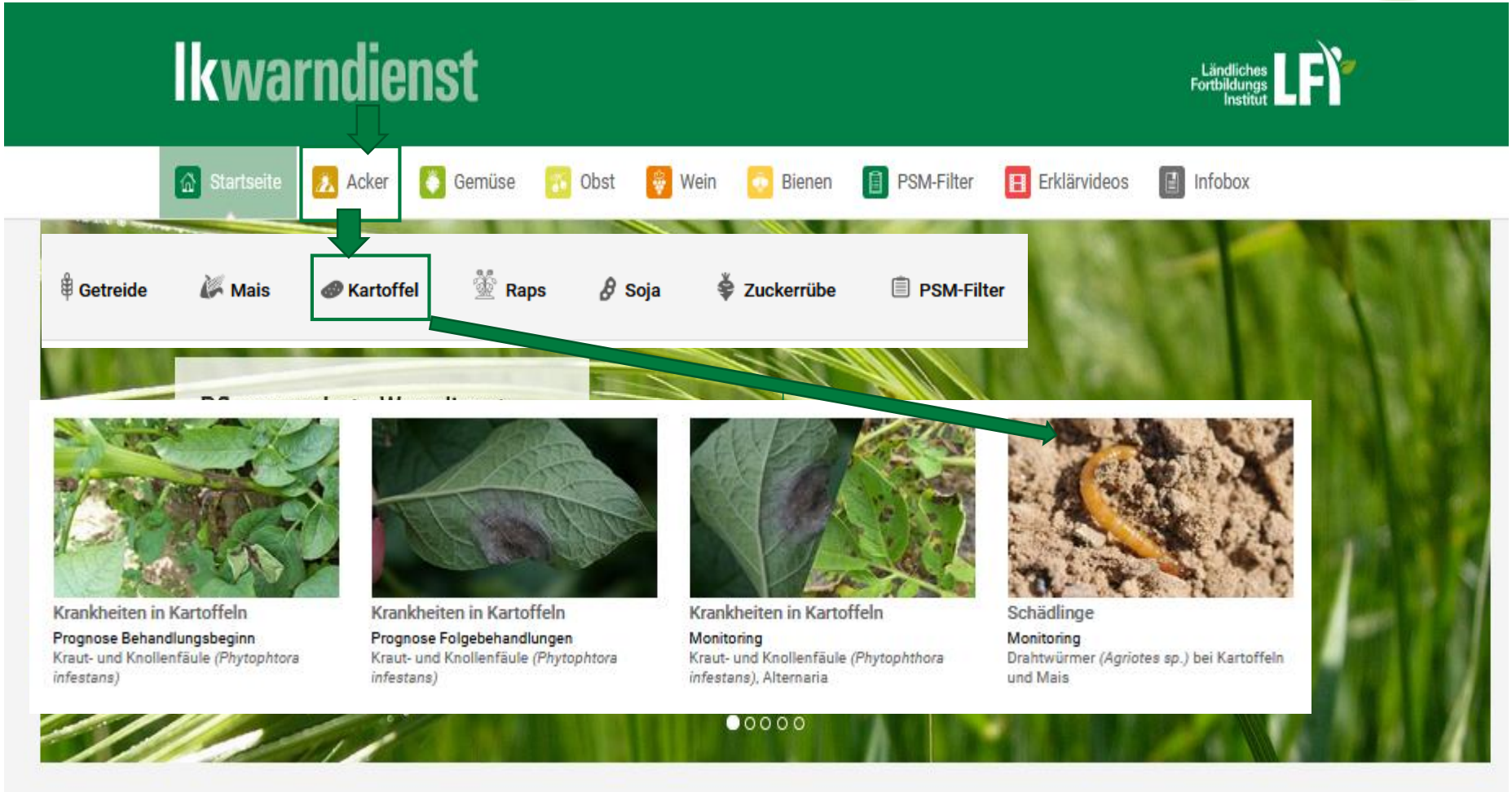
Monitoring *Agriotes sp.*, project ELATMON



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The aim of monitoring

- Distribution of the most important wireworm species and any dispersal trends
- Collection of flight activities of adult beetles at regional level in Austria

Purpose:

The control of click beetles and their larvae (wireworms) in a more targeted and timely (vulnerable) manner:

- E.g. tillage, at the right time of oviposition, young larvae …
- E.g. species-specific fungal preparations

➢ Standardized data for validation / development of forecast models (e.g. flight activity)

– Forecasting the regional yearly wireworm damage risk based on weather data and additional factors would allow farmers and advisors to plan and take measures at the right time

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Methodology

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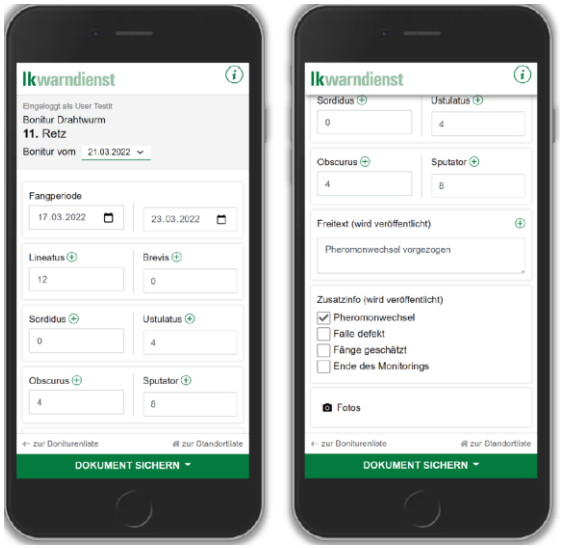
A. lineatus
A. brevis
A. sordidus
A. ustulatus
A. obscurus
A. sputator

Mob. App.



- Species specific pheromon traps for six *Agriotes sp*. from Fa. Csalomon (HU)
- Evaluation takes place every week (trained farmers, small compensation)
- Weather data: BOKU-Met
- Monitored data is published directly on the website warndienst.at

https://warndienst.lko.at/drahtwurm+2500++1075665+6637

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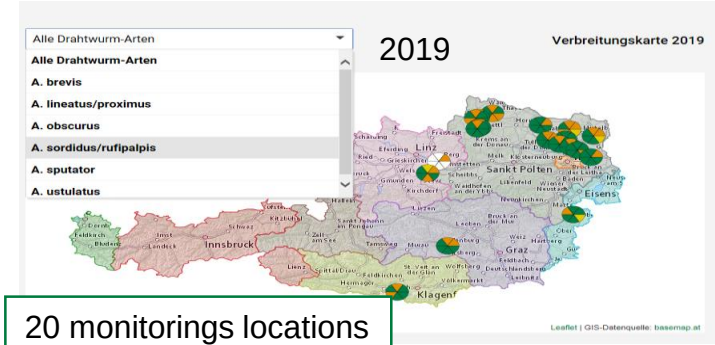
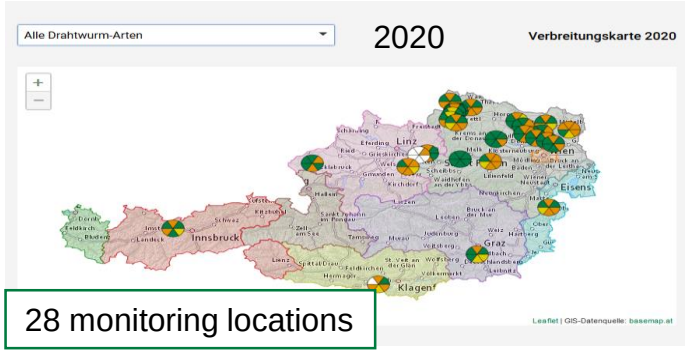
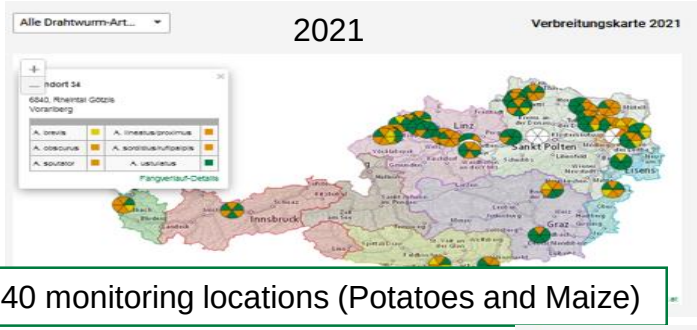
Locations of monitoring from 2019 to 2023



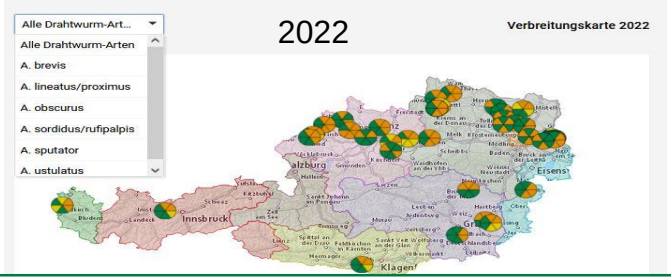
20 monitorings locations



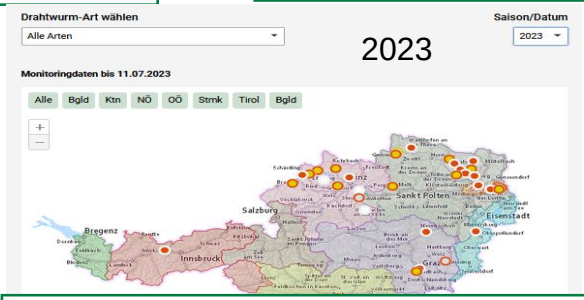
28 monitoring locations



40 monitoring locations (Potatoes and Maize)



more than 40 monitoring locations (Potatoes and Maize)



38 monitoring locations (Potatoes and Maize)

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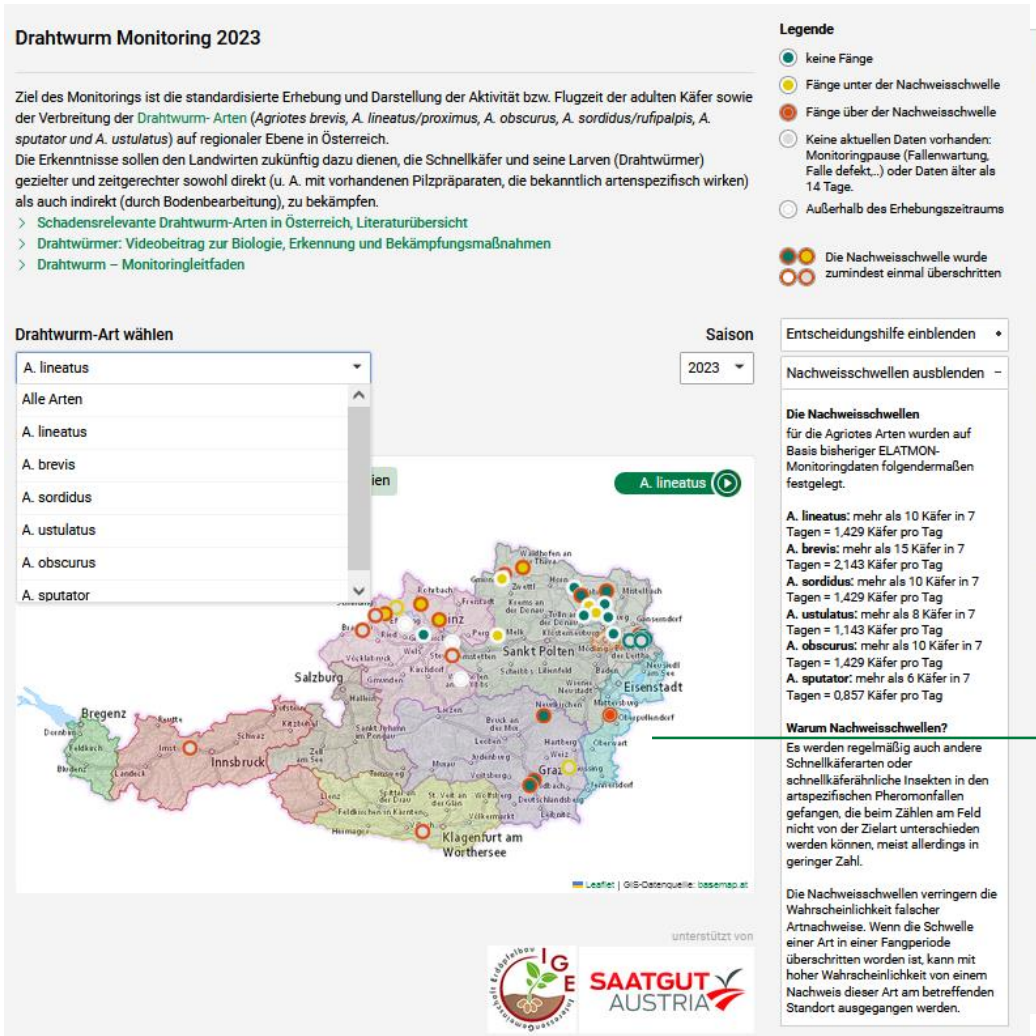
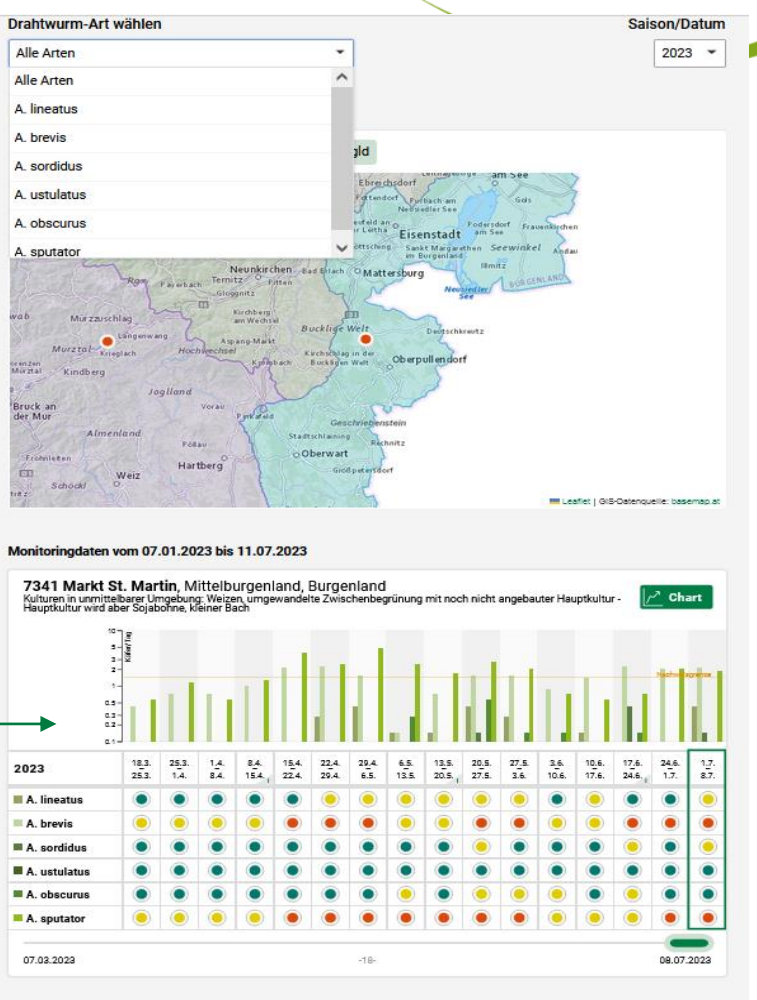
Monitoring-Map 2023





Informs about the current infestation situation and whether the damage threshold of proof has been exceeded

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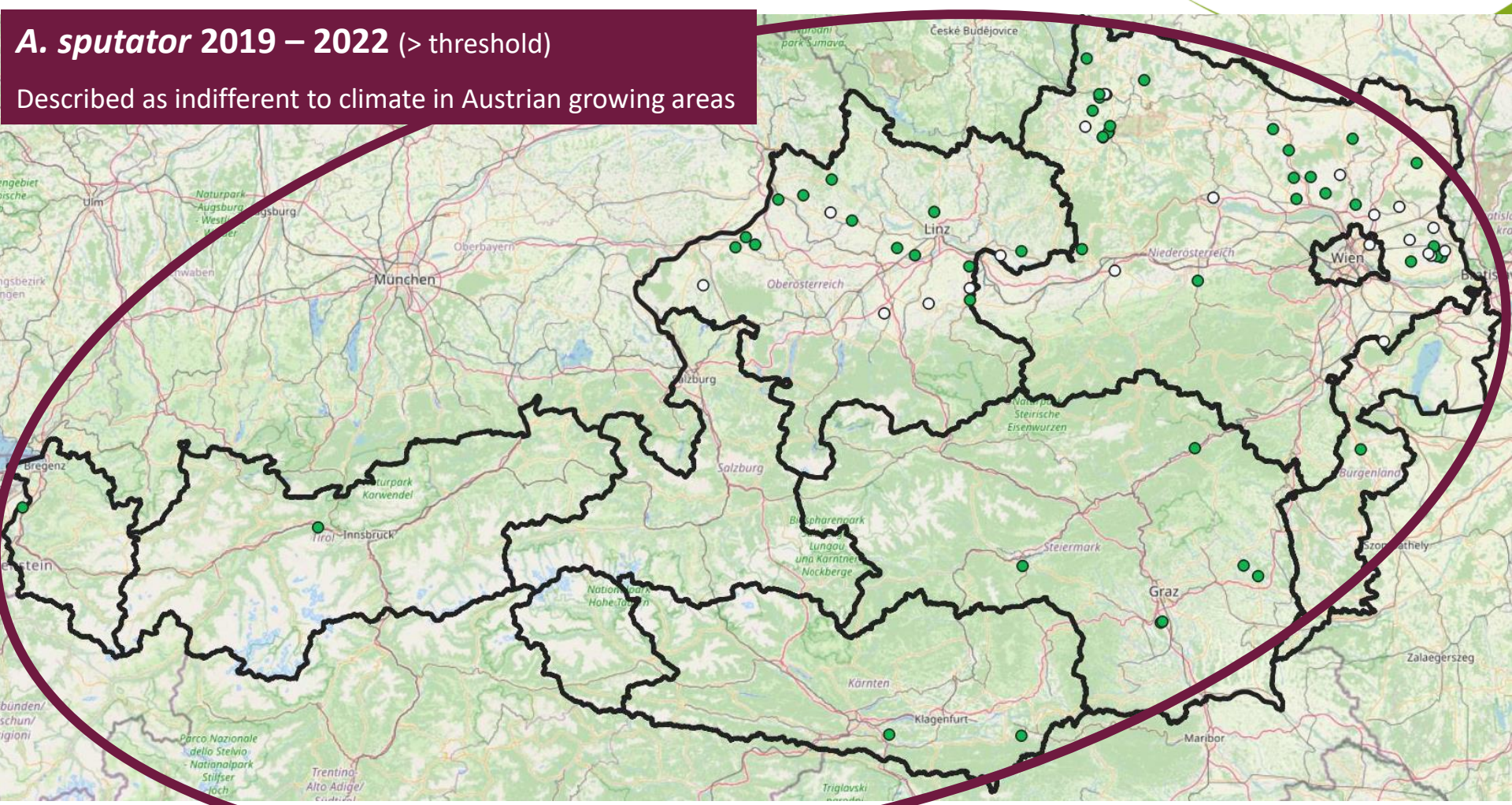
Results: *Agriotes sputator*

A. sputator 2019 – 2022 (> threshold)

Described as indifferent to climate in Austrian growing areas



A. sputator Maximum ≤ 1,43 Beetle/day

A. sputator Maximum > 1,43 Beetle/day

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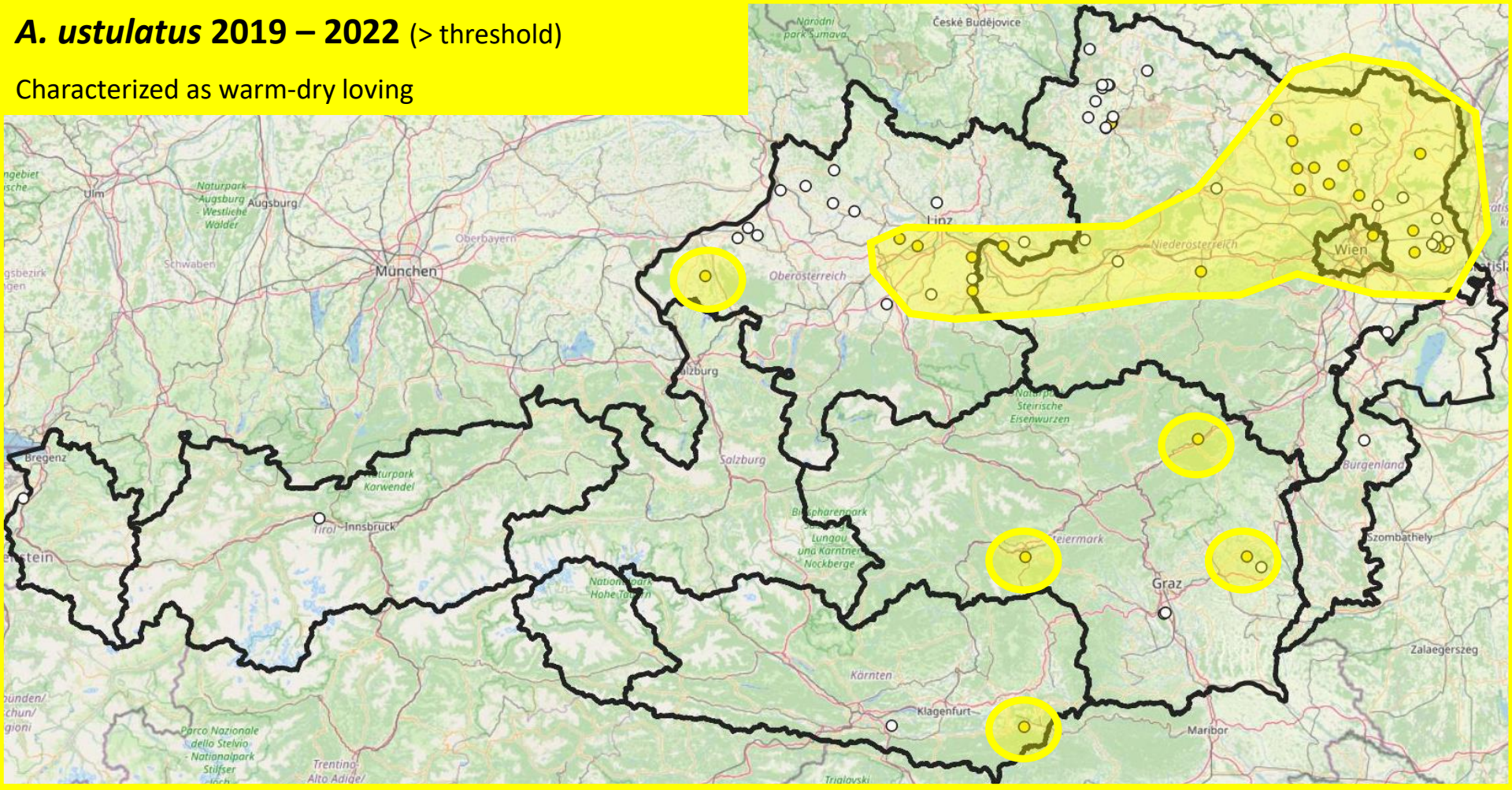
Results *Agriotes ustulatus*

***A. ustulatus* 2019 – 2022** (> threshold)

Characterized as warm-dry loving



A. ustulatus Maximum ≤ 1,43 Beetle/day

A. sputator Maximum > 1,43 Beetle/day

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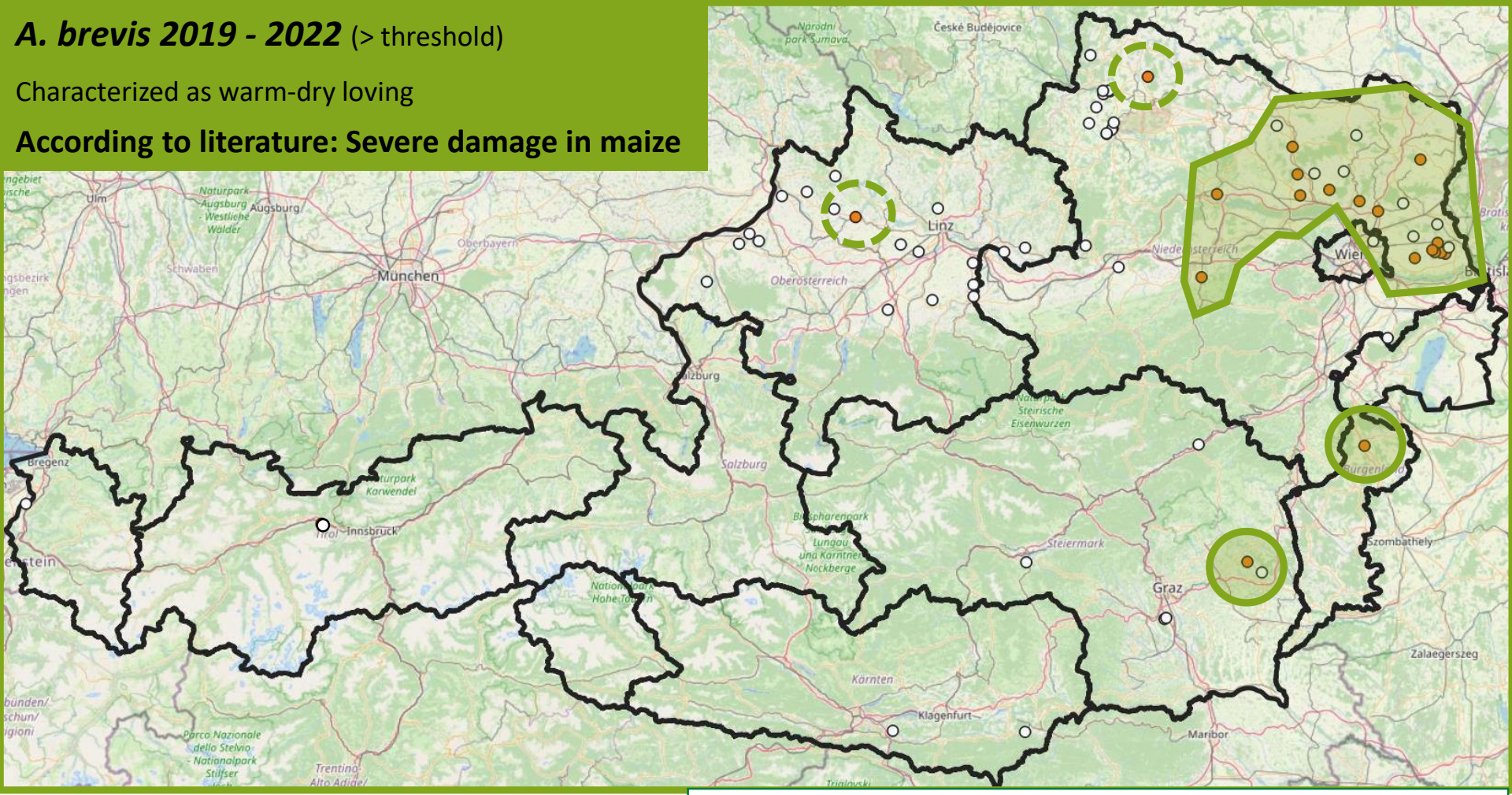
Results *Agriotes brevis*

A. brevis 2019 - 2022 (> threshold)

Characterized as warm-dry loving

According to literature: Severe damage in maize



A. brevis Maximum ≤ 1,43 Beetle/day

A. brevis Maximum > 1,43 Beetle/day

The dashed circles show regions with "weaker occurrence".

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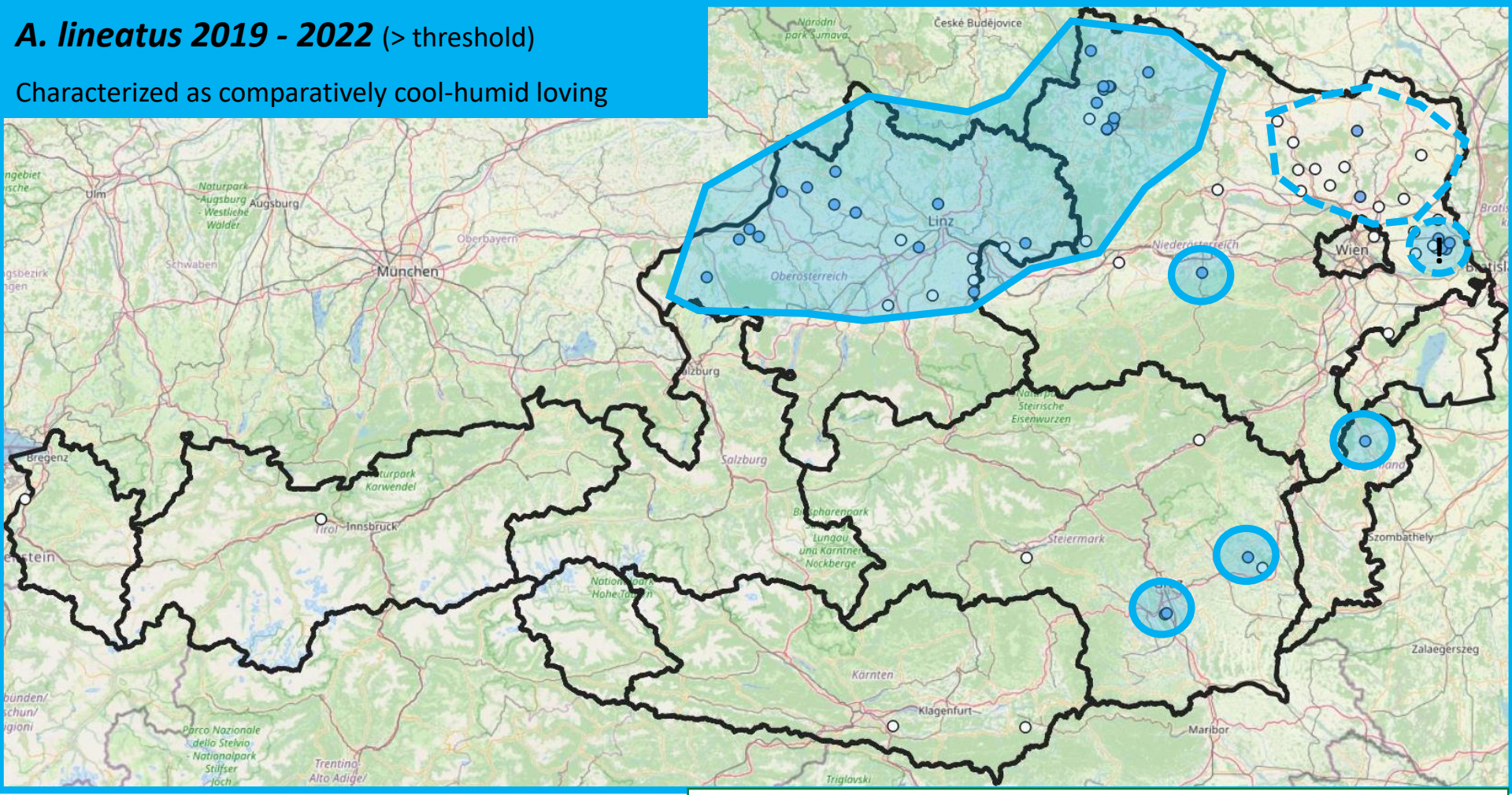
Results *Agriotes lineatus*

***A. lineatus* 2019 - 2022** (> threshold)

Characterized as comparatively cool-humid loving



The dashed circles show regions with "weaker occurrence".

A. lineatus Maximum ≤ 1,43 Beetle/day

A. lineatus Maximum > 1,43 Beetle/day

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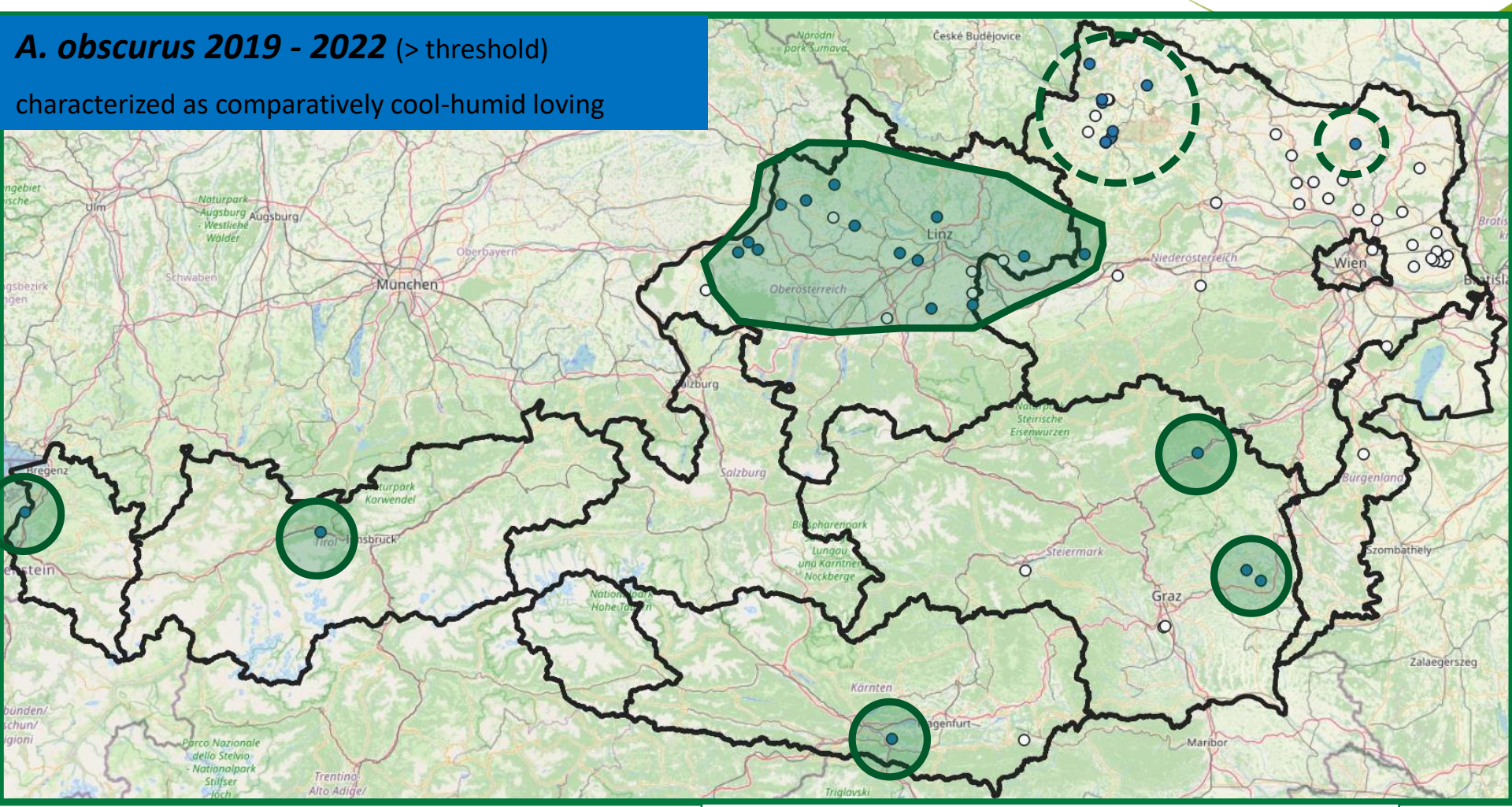
Results *Agriotes obscurus*

A. obscurus 2019 - 2022 (> threshold)

characterized as comparatively cool-humid loving



A. lineatus Maximum ≤ 1,43 Beetle/day

A. lineatus Maximum > 1,43 Beetle/day

The dashed circles show regions with "weaker occurrence".

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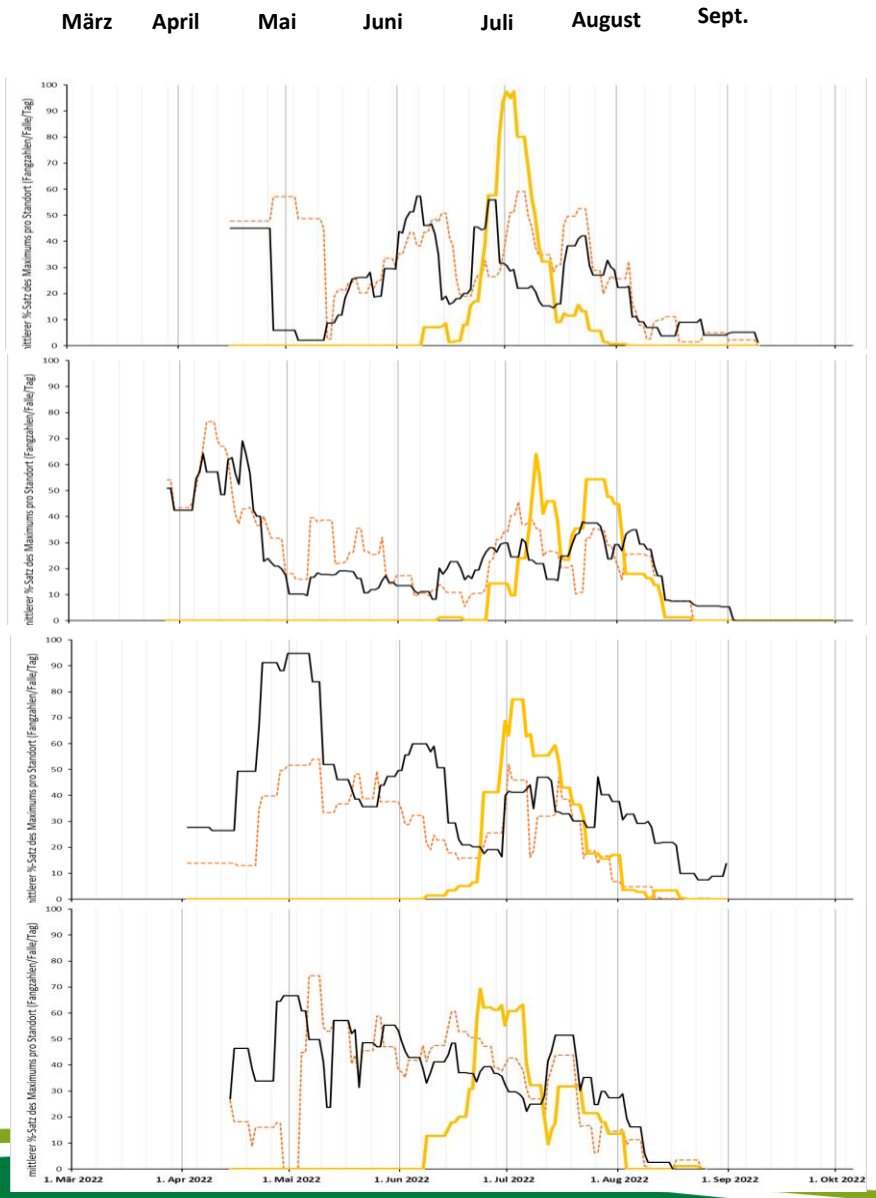
Regional flight activity – in progress



- **Regional flight activity (%)**
  highest value at W**einviertel**

- Weather data is also co-evaluated and runs in the background

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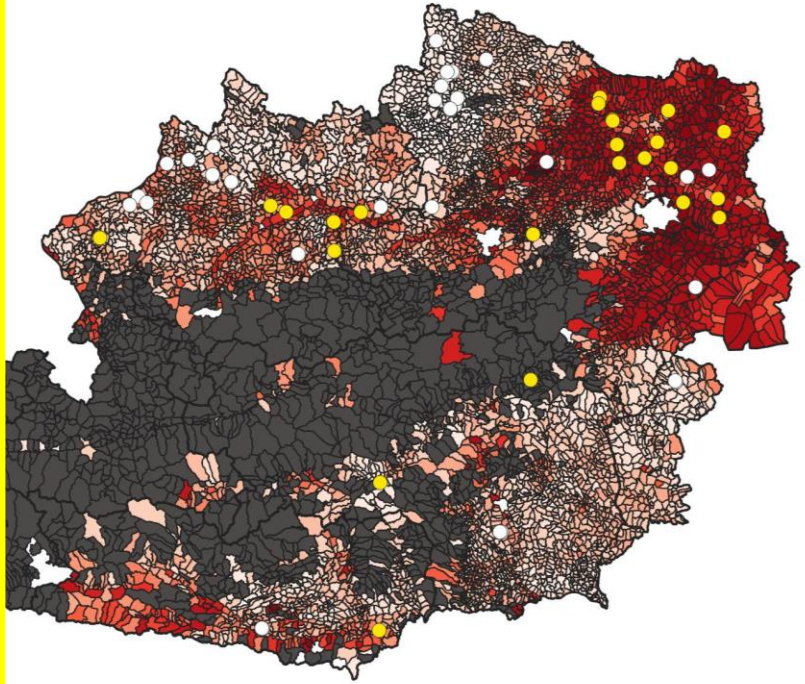
Forecasting model – in progress

Multivariate logistic regression, calculation of the probability of strong occurrence of species based on environmental variables

A. ustulatus

Basis: Soil PH (+)

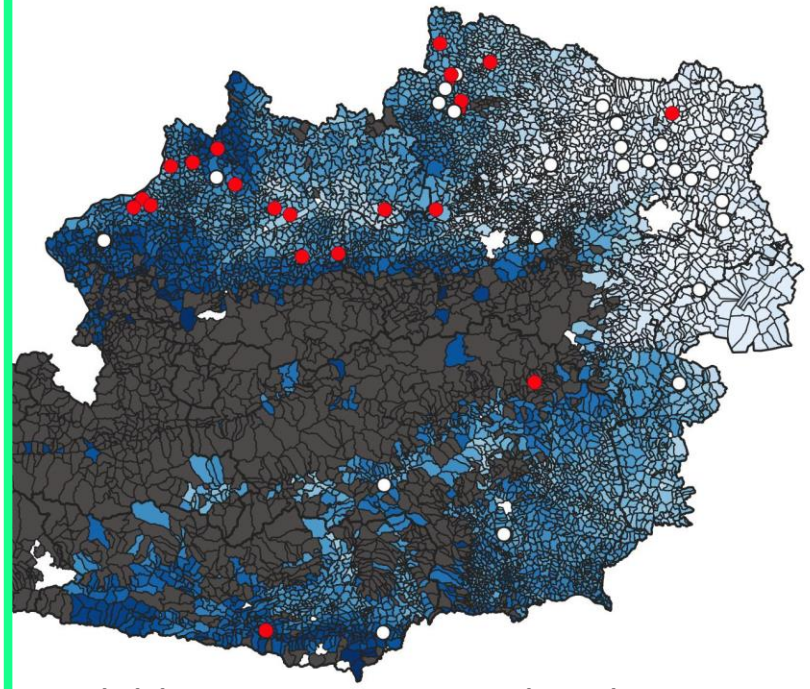


Probability
< 1 % □
> 80% ■

Max catch numbers
≤ 1.9 Beetle/catch day ○
> 1.9 Beetle/catch day ●
gray = grassland > 75 %

A. obscurus

Basis: Soil PH (-), precipitation (+)



Probability
< 1 % □
99% ■

Max catch numbers
≤ 1.43 Beetle/catch day ○
> 1.43 Beetle/catch day ●
gray = grassland > 75 %

Results and conclusions

- *A. sputator:* we calculated that occured throughout Austria, but did not cause main damages in every crop and region
- *A. ustulatus:* more likely to occur in warm dry growing regions of Austria (climate change)
- *A. lineatus and A. obscurus* rather in cool humid regions of Austria (tending to the western part of Austria)
- *A. brevis:* this specy is also widespread in warm-dry regions, tending to the eastern part of Austria
  It is certainly an issue for maize
- *A. sordidus: this specy has not yet appeared in significant numbers, at least not in post-determined ELATMON samples. There is no evidence so far that it plays a role in Austria. However, a possible spread in Austria should be further monitored*

➢ *AGES (Austrian Agency for Health and Food Safety Ltd.) - conducts surveys to determine the damage of the individual Agriotes species (sampling from farmers)*

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Results and conclusions

- The click beetle monitoring in Austria is carried out with female sex-pheromones that specifically attract males of *Agriotes* species
- However, no pheromones are available for other economically relevant click beetle genera, such as *Melanotus, Selatosomus* and *Hemicrepidius*
- Trap systems that also attract female click beetles would further improve the quality of the click beetle monitoring
- Since the available trap systems have proven to be unsuitable to catch female click beetles and economically relevant non-*Agriotes* click beetle genera, new scent mixtures are being developed
- For this purpose, scent samples were taken from grass clippings that are attractive to *A. sputator* and *A. brevis*
- The next step would be to develop new synthetic scent mixtures for the attraction of female click beetles

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ELATMON Project - Team

- DI Dr. Vitore Shala-Mayrhofer (LKÖ / LFI) — Project leader
- DI Anita Kamptner (LK NÖ) — Project coordinator
- Dr. Patrick Hann (MELES GmbH)
- Mag. Katharina Wechselberger (AGES)
- Dr. Marion Seiter, Jakob Angerer (LK OÖ)
- Univ. Prof. DI Dr. Josef Eitzinger (BOKU-Met)

Implementation monitoring, professional part

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BOKU

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AGES Österreichische Agentur für Gesundheit und Ernährungssicherheit GmbH

Ingenieurbüro für Biologie MELES

Interessengemeinschaft Erdäpfelbau IGE

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