

# Wireworm

## Unintended consequences and risk management around IPM

Martyn Cox



# The background to our problem

- Wireworms were a major threat to UK food security in WW1 & WWII.
  - Our only survey for England & Wales of the pest was carried out 1939-42
  - Agriotes were identified as the main pest species.
  - Some sites had few or no Agriotes though, notably the Fens and upland areas.
- Organochlorines largely solved the problem until they were withdrawn.
- Organophosphates and carbamates provided control in later years
- A resurgence of the pest was seen in the 1990s, then mis-named “Arable Wireworm”



# The background to our problem

- Wireworms have always been closely linked with grass, and still are.
- Problems can occur without a history of grass and this was noted in the 1990s
  - Set-aside was seen to contribute to survival
- Following the loss of aldrin, growers could reduce damage in potatoes by using Mocap (ethoprophos), and this worked well, until;
  - **In December 2019 we lost Mocap**
  - It had masked the problem for decades.
  - Risk assessment in the UK was not up to date and bait trapping was completely unreliable.



# The background to our problem

- We had not prepared for life “post Mocal” and had not realised how big the sticking plaster actually was.
- Think progress on BYDV, Virus yellows, TuYV etc since we lost neonic ST
- There was no “Plan B”
- AHDB were testing Lambda cyhalothrin granules for potatoes
  - It has not been approved here yet....
  - Problems continue to increase





# The background to our problem

- I manage £millions of salad potato production in Norfolk, on one farm alone, we have no chemical control, Nemathorin is not an option.
- Our **risk assessments** were not good enough, damage was appearing “randomly”
- We inspected behind de-stoners as our risk assessment method.
- We had to “sort it out” or “get out”
- I decided to see what I could find.



# The background to our problem

- The available advice in UK was not terribly useful.
- But, a lot of information is out there, you just have to look.
- Plenty of work had been done in Europe and Canada
  - Really good work in Europe on risk assessment for IPM
  - Similar conclusions in Canada
  - We had some good pointers.



I started work on a wireworm review for CUPGRA members with Dr Marc Allison.



# Progress is made

- After 18 months, we published a comprehensive review into the situation.

## Useful findings

- The critical conditions for activity of larvae, and this holds for the UK
- We proved beyond any doubt that potato damage starts early, when tubers form.
- Greatly improved risk assessments
- Better understanding of the species involved
- Species identified by DNA in Austria (I paid for this)
- Management in the rotation identified as the major action point required.





# Progress is made

## Questions around at the time:

- Why was it getting worse?
- Have the species changed?

## Species

- I.d. of larvae is very difficult/impossible by visual methods
- Identification by DNA barcoding is available, not in the UK.
- It is neither easy or cheap!





# Progress is made

DNA identification by Sinsoma 2022

Cambs	<i>Adrastus pallens</i>	2
Norfolk	<i>Adrastus pallens</i>	2
Somerset	<i>Agriotes lineatus</i>	1
Suffolk	<i>Agriotes lineatus</i>	2
Bucks	<i>Agriotes obscurus</i>	1
Norfolk	<i>Agriotes obscurus</i>	1
Cambs	<i>Agriotes obscurus</i>	2
Suffolk	<i>Agriotes sputator</i>	5
Cambs	<i>Hemicrepidius niger</i>	1
Norfolk	<i>Hemicrepidius niger</i>	1

← Not a problem

← Not expected



# Progress is made

- I spoke to Dr Larissa Collins who was aware of increasing wireworm problems.
- In a short space of time, Fera were able to launch

## ENIGMA

A fera led collaborative R&D model 

- **Enigma 1 objectives include**
  - **WIREWORM IDENTIFICATION SERVICES**
  - **WIREWORM MONITORING RESOURCES**
  - **PREDICTIVE MODELLING TECHNIQUES**
  - **DECISION SUPPORT TOOLS**



  
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# Progress is made

# ENIGMA

A fera led collaborative R&D model 

- INOV3PT from France are partners in Enigma, this brings extra depth to the project.
- Other projects in UK
- Swansea university (EPF/EPN, attractants, plant based sterilants and other work)
- Rothamsted (Jozsef Vuts) attractants
- Branston Ltd: Hyperspectral cameras identifying populations
- CUPGRA: Variety damage work and KE to members
- My work is largely on risk assessment and management in a rotation



  
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# Some background

- Wireworm are the larvae of click beetles (Elateridae)
- Around 10,000 species worldwide
- Around 70 species of 38 genera in UK
  - Few are crop pests
  - Six species of Agriotes recorded in UK.
  - Other species can damage crops
  - Agriotes are not the dominant genus everywhere.
  - But appear to be the major problem in most cases.



# Wireworm

## Attraction to plants and movement

- Wireworms move up a  $\text{CO}_2$  concentration gradient (orthokinesis) to find a food source.
- Other root volatiles are involved and attraction does vary between plant species.
- Sugars, are favoured and glucose in particular is known to elicit a biting response.
- Larvae can move 20 -50cm to a bait trap, estimates vary, so does soil!
- Under field conditions, movement of 3-4m has been quoted (C Noronha) and they can move across the soil surface to find food.



# Wireworm

A little bit on other crops.





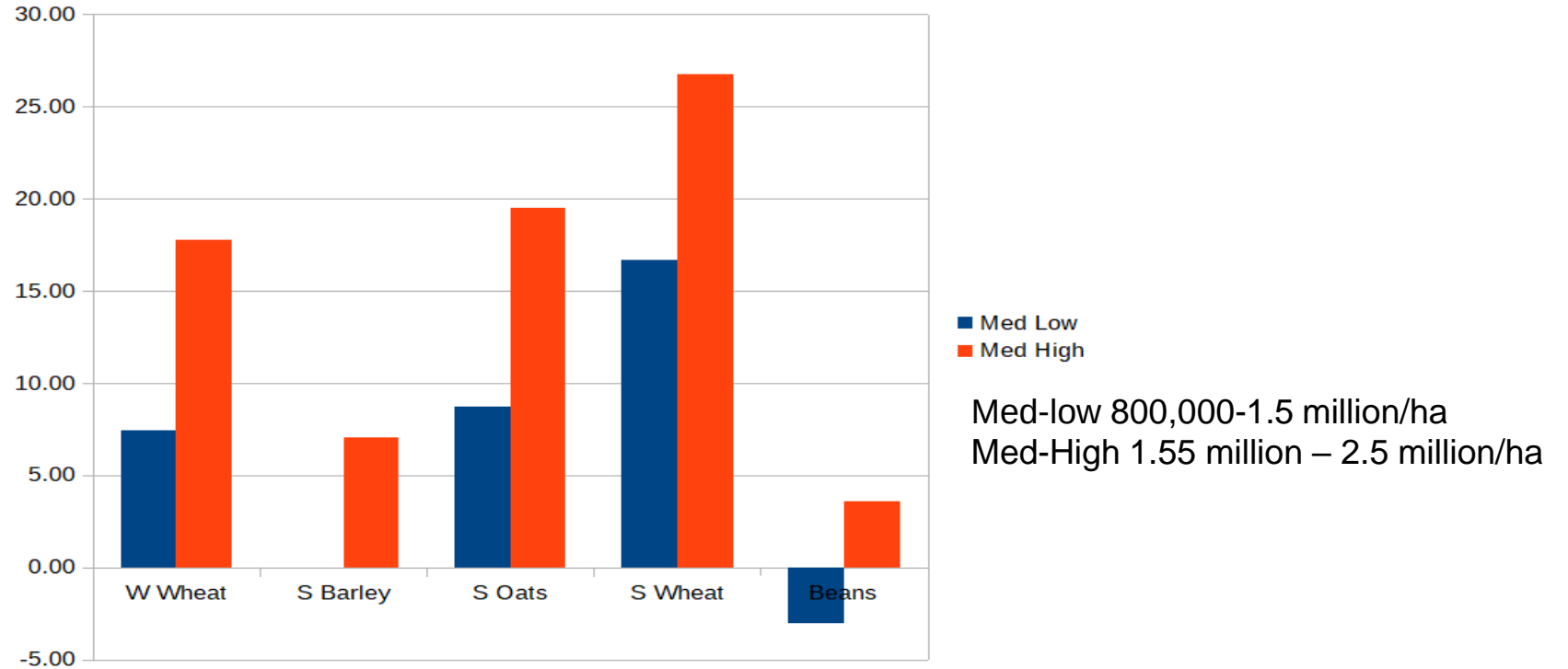
# Damage in various crop species

- **Wireworms will damage cereals, grass, maize, potatoes, carrots, onions, leeks, lettuce, asparagus, sugar beet and a variety of other crops.**
- Lettuces can be lost within 2 days of planting.
- Crop damage is increased by crows & rooks
- Parsnips, and Buckwheat seem immune or non feeding species. Linseed is rarely damaged
- **Damage is appearing in cereals now, particularly after long term stewardship.**
- **Wireworm threatens to hamper the ambitions for net zero.**
- Some background information, follows, some is very old



# Yield loss % different crops 1941-42

Percentage yield loss at two population categories



**Spring beans will survive where winter wheat has failed.  
Spring barley & linseed also quite tolerant**

1944 Fryer



# Damage and species

Damage by larvae of three genera to seeds and plants of oats or wheat from Edwards & Evans 1950

Pest Species	Crop species	Seeds destroyed	Seedlings destroyed
Corymbites cupreus*	Oats	86	9
Corymbites cupreus*	Wheat	87	7
Agriotes (unspecified)	Oats	66	8
Agriotes (unspecified)	Wheat	68	3
Athous niger*	Oats	20	1
Athous niger*	Wheat	22	5

Corymbites cupreus is now classified as Ctenicera cuprea. Athous niger is now known as Hemicrepidius hirtus (UKSI) or H. Niger.

See <https://species.nbnatlas.org/search?fq=idxtype%3ATAXON&q=athous> or <https://www.gbif.org/species/6983233>

Source: Edwards & Evans 1950





# Timing of meadow ploughing

Long-term research was carried out in north-eastern Italy to assess the potential of meadow ploughing just before maize sowing to prevent wireworm damage.

- Damage was lower if ploughed **just before** maize sowing
- And **higher** if plots were **ploughed** in **autumn-winter**
- Plant damage in pots with soil incorporated fresh meadow turf was significantly lower than that observed in pots without.
- Studies have also shown damage is much lower when maize is drilled into soil above 12C

Meadow-ploughing timing as an integrated pest management tactic to prevent soil-pest damage to maize  
Lorenzo Furlan, Isadora Benvegnù, Francesca Chiarini, Donato Loddo, Francesco Morari  
European Journal of Agronomy 112 (2020)



# Damage and thresholds

- The threshold for winter wheat is quoted at 750,000 per ha

## Conclusions made during WWII still hold true

- On **heavier soils**, the power of recovery from attack appears to be more marked than **on lighter** soils.
- The degree of **consolidation** which a heavy soil naturally tends to assume, may be an important factor.
- It may also have some direct effect in **retarding the movement of wireworms** in the soil, thus reducing the number of plants attacked by any individual.

## Advice for winter cereals

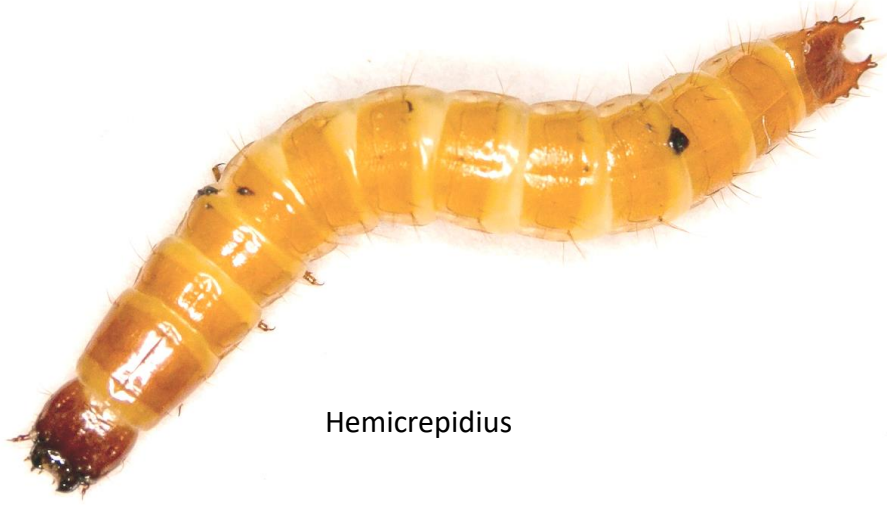
- Drill earlier, possibly a strong tillering variety
- Consolidate the soil
- Do not drill too deep
- Use Signal ST which can reduce early damage
- In high populations other crops such as spring beans may be more suitable

Fryer 1944



# Wireworms, different genera

Two are not serious crop pests?



Hemicrepidius



Adrastus



Agriotes

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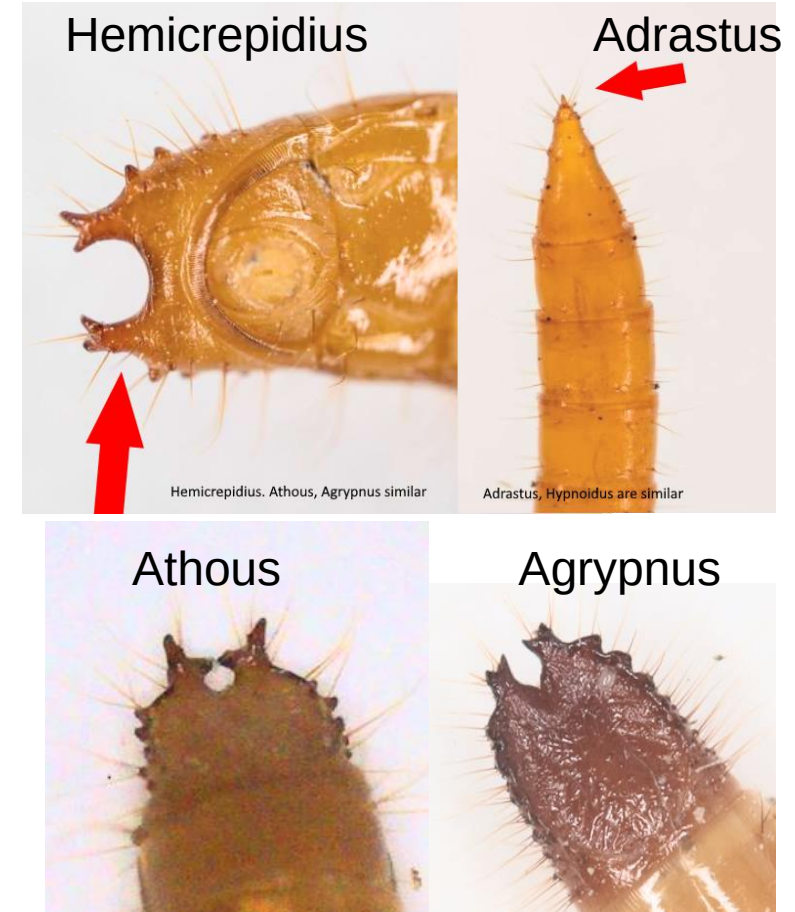
# Wireworms some different genera

Farmers and agronomists are now more aware of the differences



Agriotes larvae

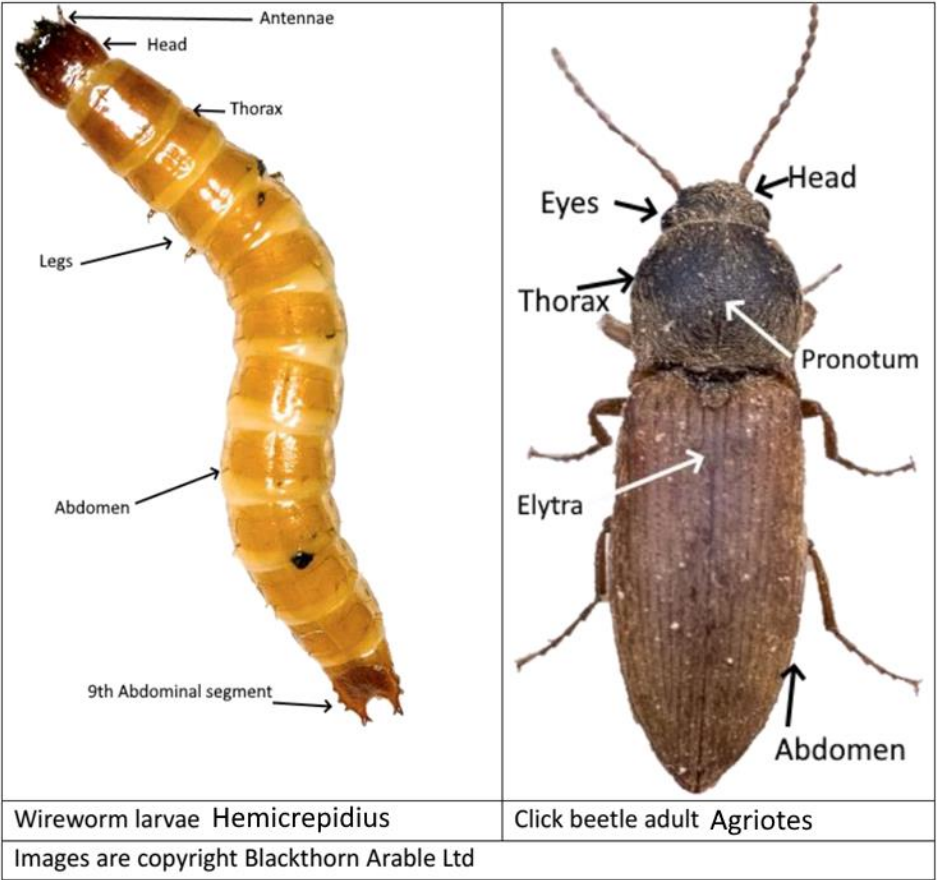
are easy “2 spot”



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# Click beetle life stages



4 YEARS?

<12 months



2-3 weeks



# Click beetle timelines

For our main Agriotes species

Spring

Adults emerge from the soil, and breed.  
Survive until late summer

May- July

Eggs hatch, larvae 1.5mm long  
Larvae live around 4\* years (depending on species and heat.

July- August

Year 4 larvae pupate\*, this lasts 2-3 weeks

Autumn

Adult beetles remain below soil surface until spring





# Click beetle life stages

- \*Larvae, 4 years?
- Swiss work, near Zurich, a similar climate to the Midlands in UK has indicated a shorter lifecycle.

Development cycle	<i>A. obscurus</i>	<i>A. lineatus</i>	<i>A. sputator</i>
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.

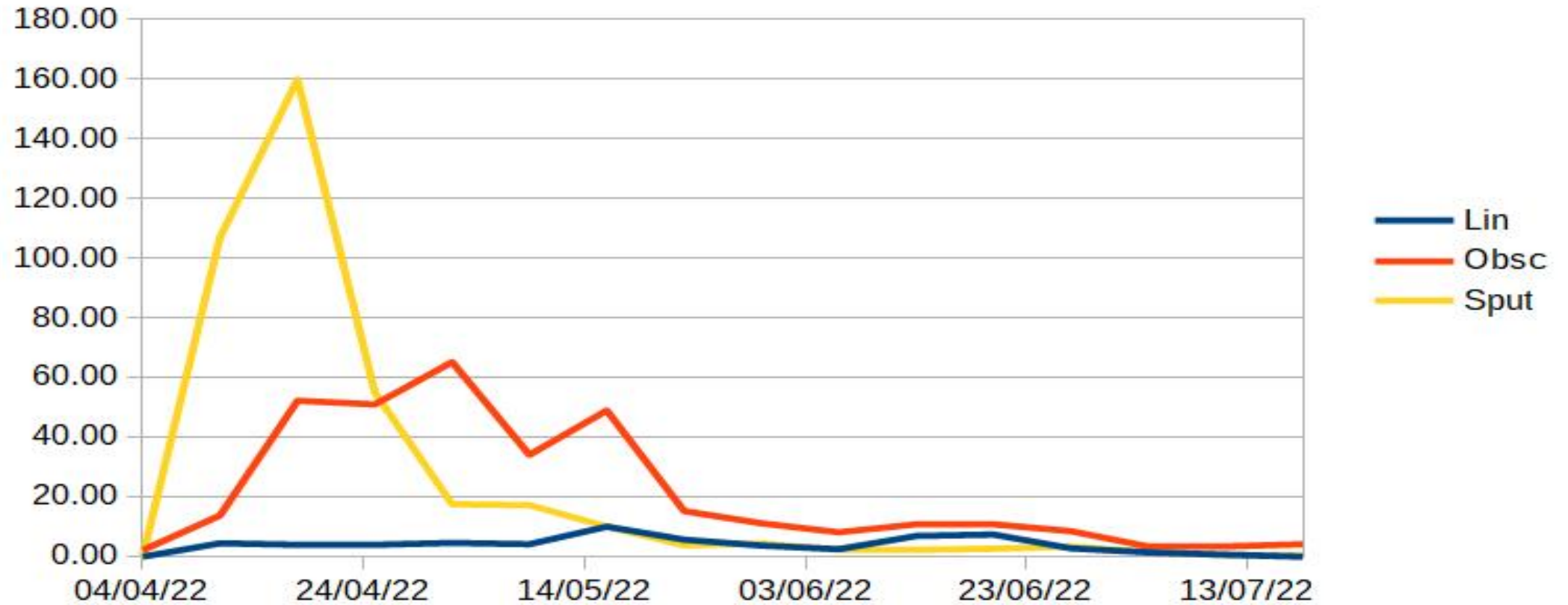
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# Click beetle adult activity 2022

Pheromone trap catches at sites in East Anglia



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# Click beetle activity 2022

Site		Adults/week	Total	WW Known
Lenwade Top	L1	72.00	648	Y
Lenwade Low	L2	73.67	663	Y
Haylocks Far UNT	H Far	39.38	315	N
Pentney 1	P1	18.63	149	Y
Brecklands	Br	152.71	1069	N?
Wissey	WF	77.67	466	Y
Corneholme	CH	83.25	666	Y
Red Lodge	RL	188.22	1694	Y



# Click beetles: Adult activity

- Monitor adult activity to enable:
- Potential to disturb sensitive stages
  - Such as when using insecticides in other crops, weevil in pulses.
  - Hoeing in sugar beet against eggs?
  - Planting date of vining peas, maize, veg.
- Identify potential risk in 2-3 years?



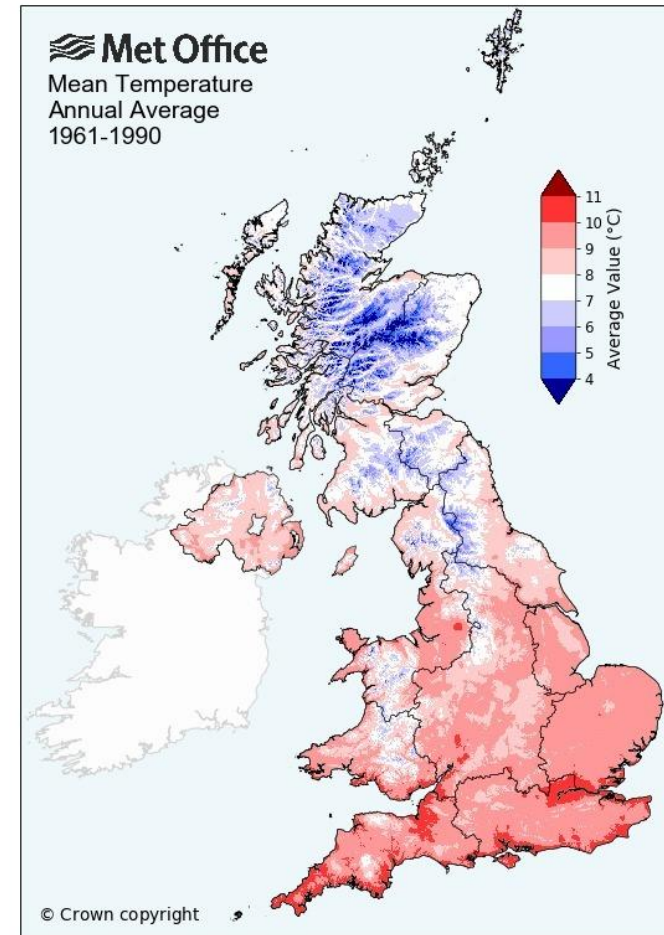
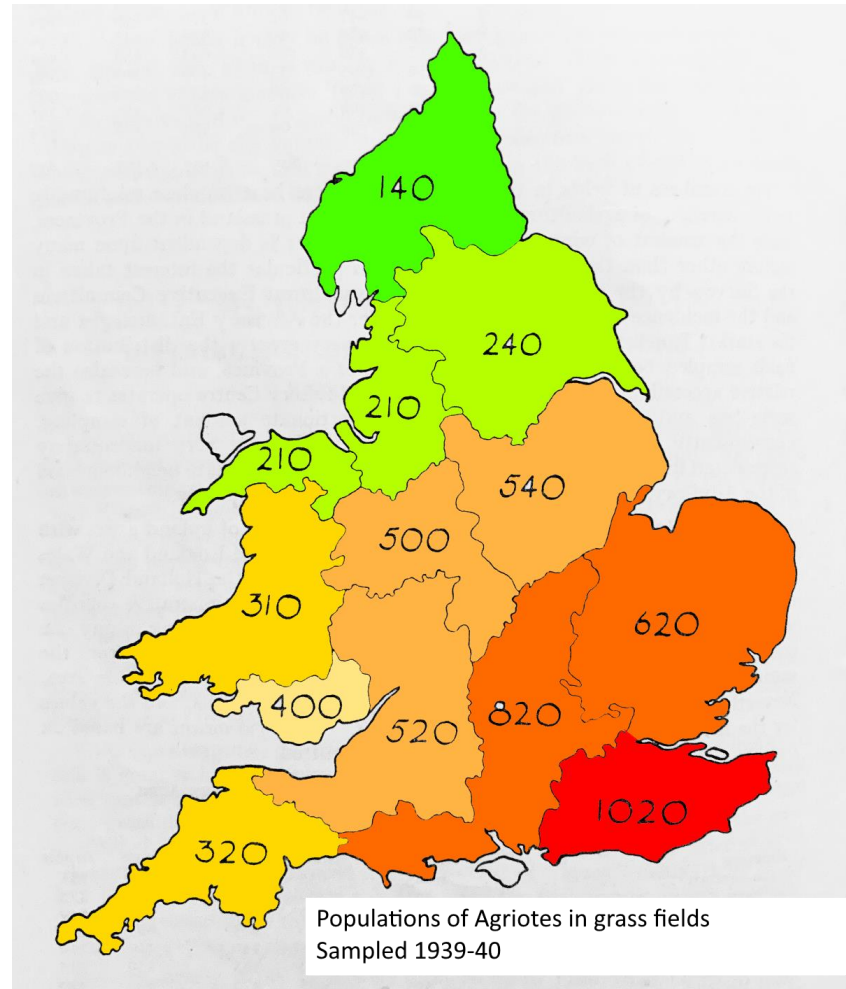
# Click beetles: Adult activity

- Previous experience was not good.
- Poor correlation between adult and larval abundance in sites
- It was tried in the UK 20 years ago but did not work well.
- **We now are aware that:**
  - No link between *Agriotes lineatus* adults and larvae
  - *A. obscurus* and *A. sputator* better fit, but still weak
  - Original UK AHDB work may have started too late
  - Did not consider the *A. lineatus* factor
  - May help predict risk in 2-3 years (Furlan)





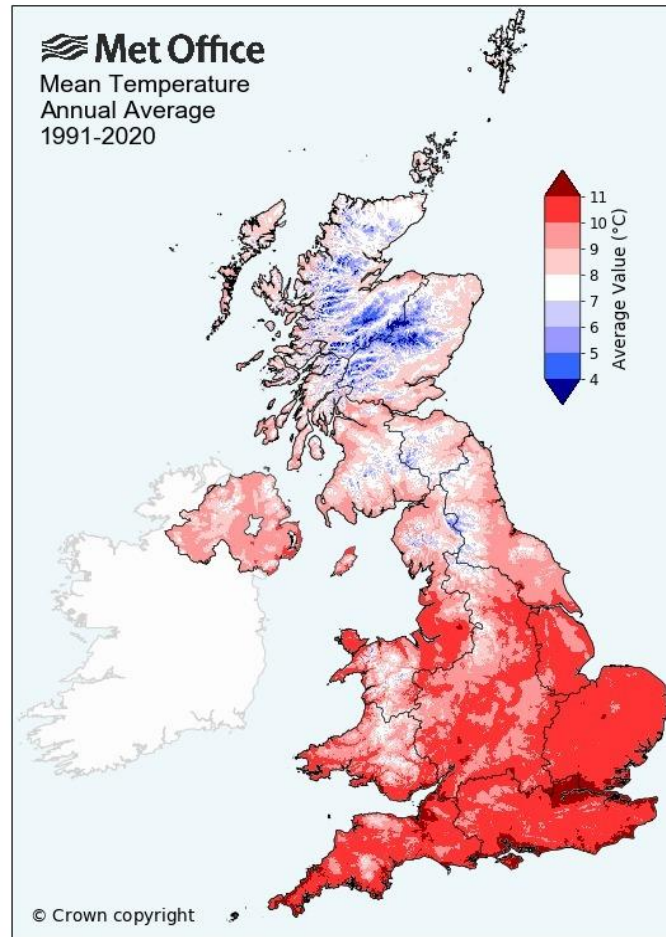
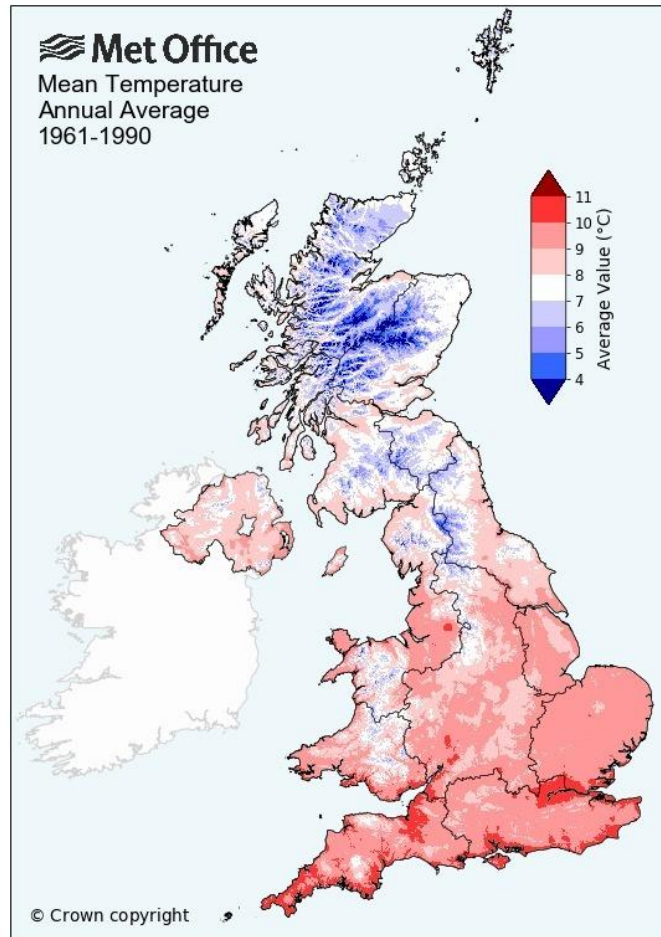
# UK Climate change



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# UK Climate change



# Why are populations increasing?

- Problems are greatest in the warmer parts of UK
- Oak trees came into leaf across the UK earlier in 2020 than in any of the previous 20 years.
- Life cycle < 5 years is likely in S England
- No evidence of major change in species





# Why are populations increasing?

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





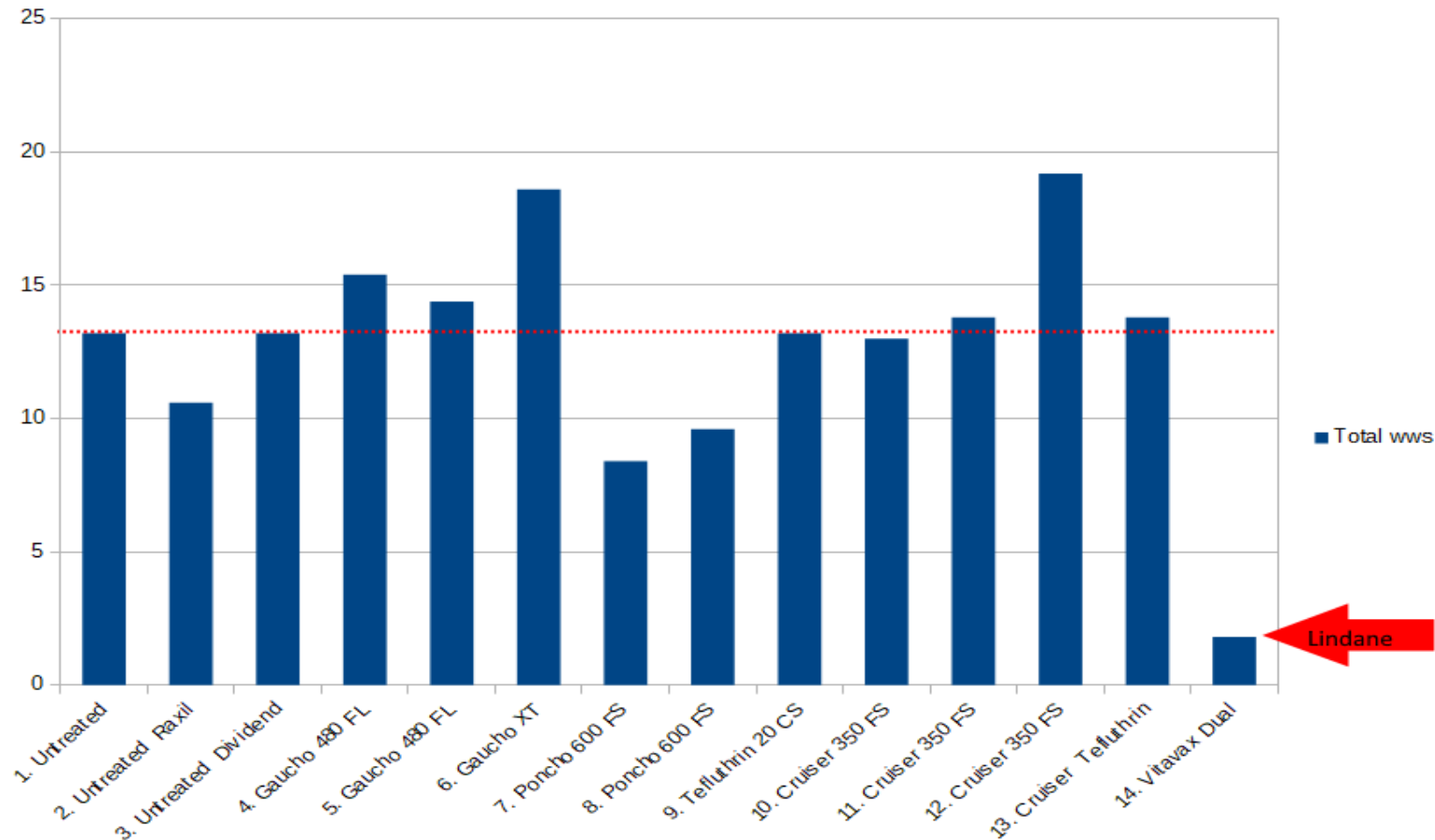
# Populations and seed treatments

- Research work has shown the effects of cereal seed treatments on wireworm populations.
- As expected, the effect, varies with the chemicals involved.
- Lindane used as a cereal ST reduced wireworm populations the following year, Fipronil was even better.
- Neonics and pyrethroids do not have such a powerful effect.
- Lole in UK showed populations do not decline with non inversion tillage.



# Populations and seed treatments

## 2005 wheat trial Wireworm populations, Assessment 2006-1



Wireworm Management I: Stand Protection Versus Wireworm Mortality With Wheat Seed Treatments

ROBERT S. VERNON,<sup>1</sup> WILLEM G. VAN HERK, MARKUS CLODIUS, AND CHANTELE HARDING

PaciPc Agri-Food Research Centre, Agriculture and Agri-Food Canada, P.O. Box 1000, Agassiz, British Columbia, Canada V0M 1A0



  
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# Risk

- We have learned that
- It is not just **what** you do
- It is **when** you do it that matters



# Risk

## New vs old risk assessment

Old	New
Grass or set aside in last 5 years	Grass or similar in last 10 or more years
South facing	South facing may favour, the pest
Lack of non inversion tillage	Tillage situation more complex
	Lack of inversion tillage in early autumn
	Green cover of most plant species in autumn
	Meadows, perennial grass nearby
	Soil OM%
	Perennial weeds, thistles good indicator
	Beside a field with a known problem





# Risk

Wireworms in a sowthistle root



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# Risk

- Highest risk (arable situations)
- No autumn cultivation (Aug/Sept)
- Some green cover, often just weedy stubbles
- Permanent grass nearby, eg river banks, meadows etc.
- Surface water bodies (rivers, reservoirs)
- Lots of cereals in the rotation





# Wireworm management



Pheromone trap

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# Risk

## Problems exist where:

- No history of grass is known
- No cover crops
- Ploughing or cultivation takes place, every year





# Identifying a population

- **Bait trapping can detect lower populations than core samples (62.5K/ha)**
- **Providing it is performed correctly**
- **Current UK advice from Syngenta**
- Conditions: When soil is warming and wireworm rise to the surface.  
Traps should be buried in the soil close to the surface and filled with a food source such as an old potato.

## Revised advice

- Timing: Spring or autumn if soil is above 8C, ideally 10C and moist (not saturated)
- Use 50-50 wheat / maize mix of untreated seed
- Plants growing nearby will reduce the effectiveness of the traps
- If any Agriotes are found, there is a risk.
- Other species need to be identified to genus and the risk assessed.



# Bait trap work 2020- 2022

- 50/50 wheat maize mix
  - Make sure your maize grows!
  - Not chemical treated
- Populations are very patchy!
- **Threshold?**
- **Non Agriotes species?**



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# Bait trap work in 2022

- Bait trapping
- Tested this year
- Pre-growing module traps
- Can catch larvae in 4 days
- No mesh, plastic etc



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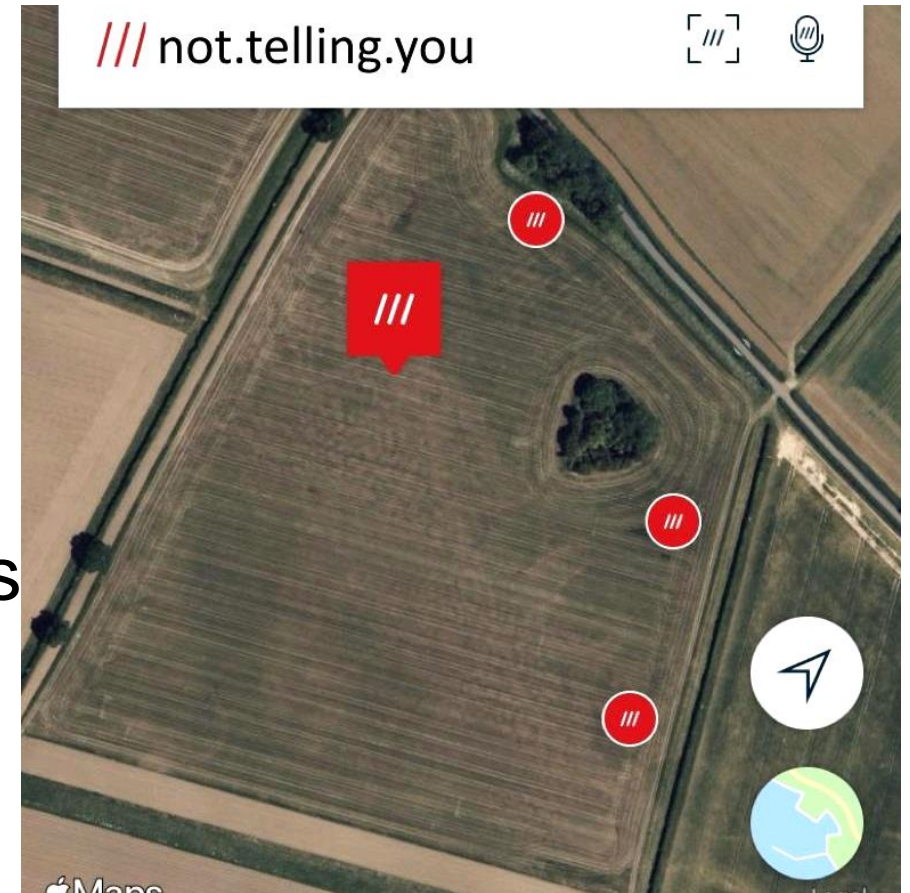


  
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# Bait trap work in 2022

- Soil capable of holding moisture
- Surface water: Humidity-risk
- Larvae found in the lower, stronger parts of **this** field (red dots)
- What3words map helped!



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# Bait trap work in 2022

- **Bait trap catches are very patchy**
- Catches in a site Oct 2022
- Agriotes, 32 in 12 traps
- Module 20 vs chitted 12
- Modules were almost dead
- In Dec, 1 larvae caught in cold / wet soil

7	4	<55M>	Module
2	4		Chitted ball
3	3		
3	6		
0	0		
<7M>			

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# Potato varieties

- Wireworms do prefer some varieties to others.
  - It is, a thing.
  - But all get damaged to some extent.
- Sugars and glycoalkaloids are involved.
- May not be the only factors though?





# Variety trial (organic site)



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# Summary

Populations are definitely on the increase again

Increasing reports of damage in cereals

Wheat crops lost after 10 year stewardship.

Potatoes are very vulnerable

Zero-till and autumn green cover increase risk

IPM in a rotation has become essential.





*Thank you*

