

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- Organochlorines largely solved the problem until they were withdrawn.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.
 - **But in December 2019 we lost Mocap** and we were not ready for this
 - It had masked the problem for decades
 - Risk assessment in the UK was not up to date.
 - Bait trapping was completely unreliable.



The background to our problem

- We had not prepared for life “post Mocap” 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

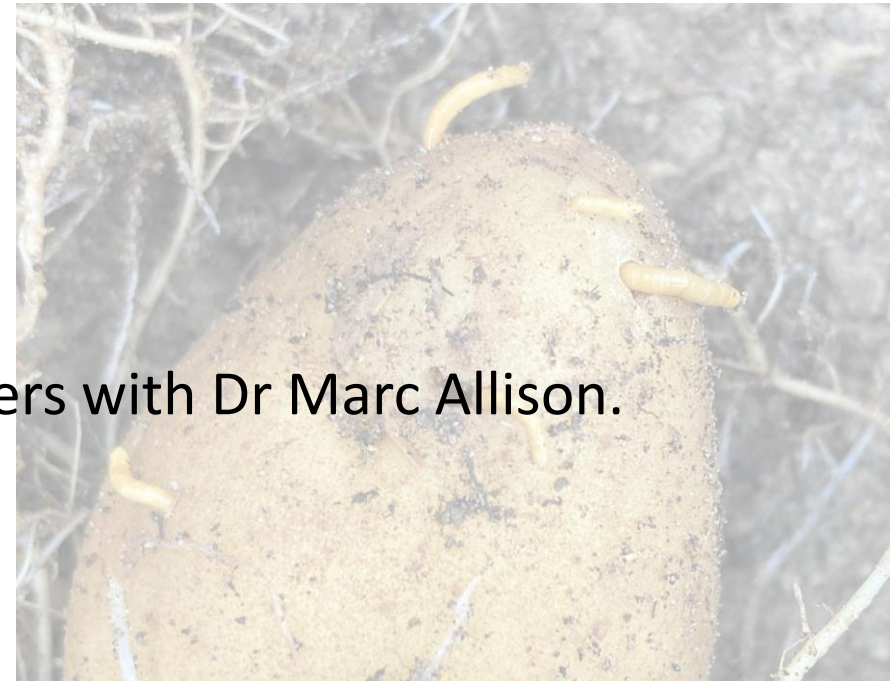
- I manage £millions of salad potato production in Norfolk, on one farm alone, we have no chemical control, Nemathorin is not an option.
- Our **risk assessments** were not good enough, damage was appearing “randomly”
- We inspected behind de-stoners as our risk assessment method.
- We had to “sort it 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.
- A lot of information is out there, you just have to look.
- A lot 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?
- Has the species changed?

Species

- I.d. of larvae is very difficult/impossible by visual methods
- Identification by DNA barcoding is available, but 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 Co₂ 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.



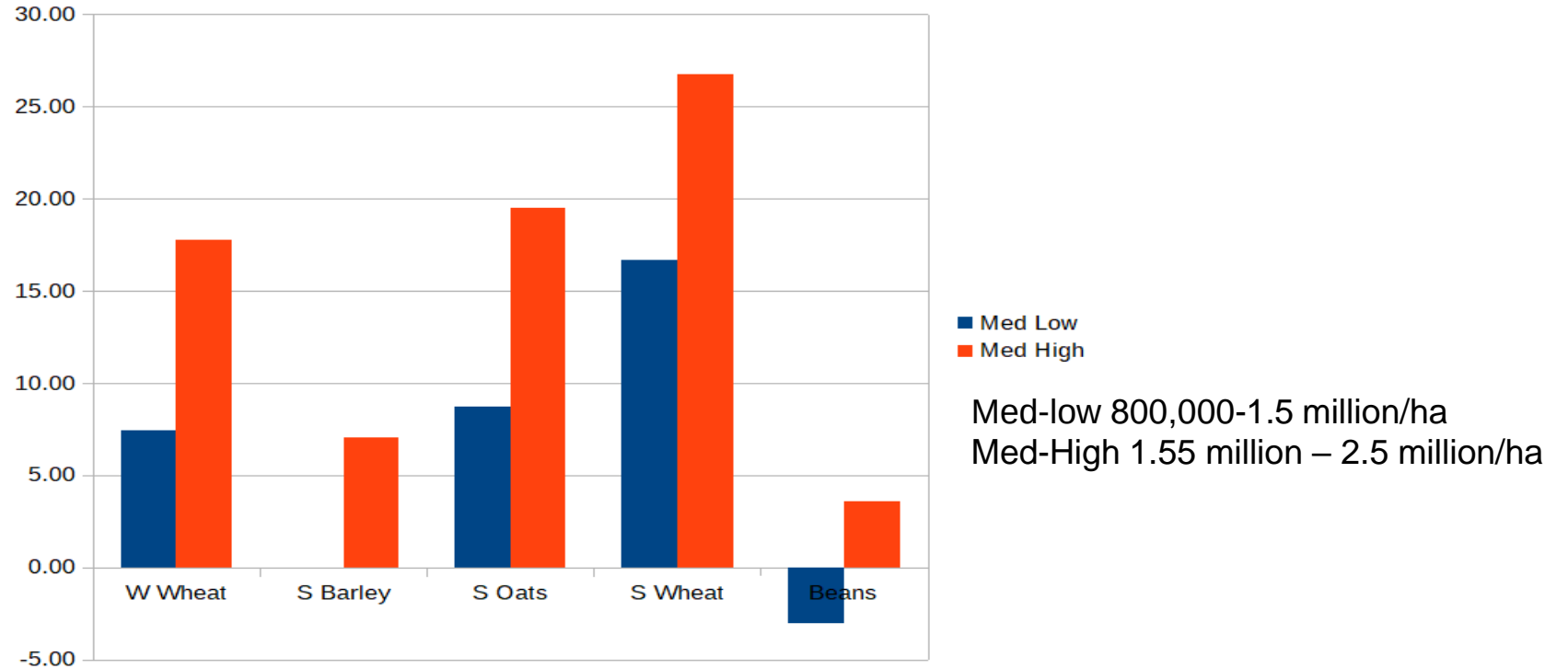
Damage in various crop species

- **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




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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=idxtyp%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)




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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

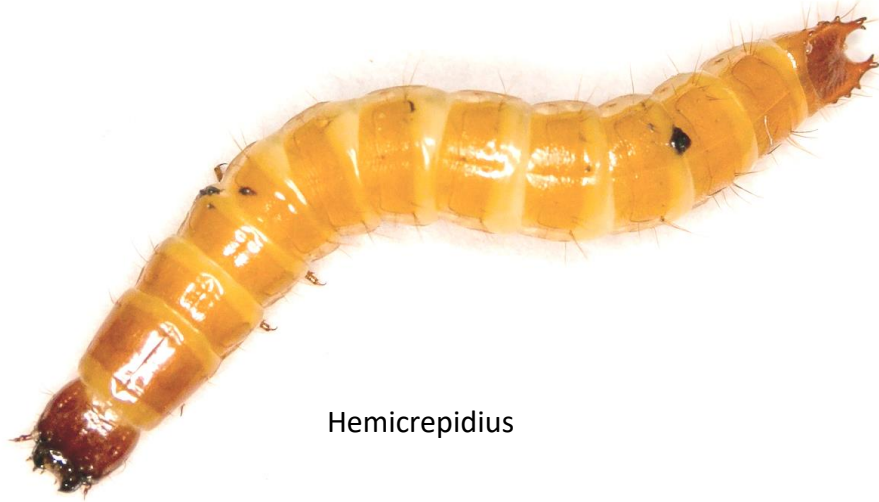
- Drill earlier, possibly a strong tillering variety
- Consolidate the soil
- Do not drill too deep
- Use Signal ST which can reduce early damage
- In high populations other crops such as spring beans may be more suitable

Fryer 1944



Wireworms, different genera

Two are not serious crop pests?



Hemicrepidius



Adrastus



Agriotes

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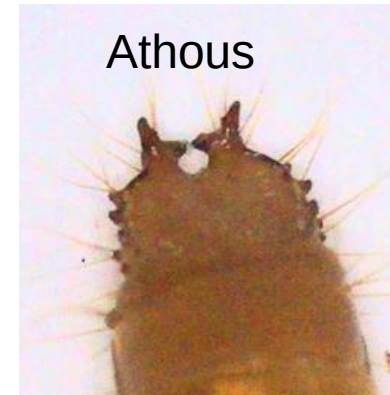
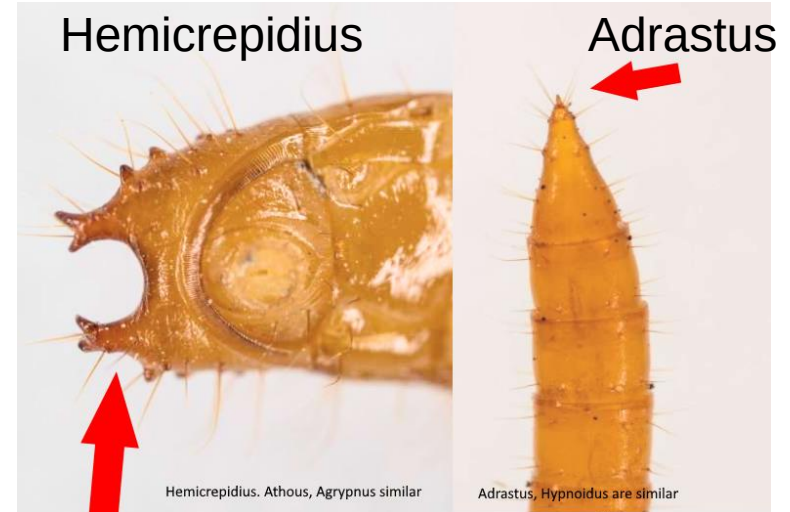
Wireworms some different genera

Farmers and agronomists are now more aware of the differences



Agriotes larvae

are easy “2 spot”



Athous

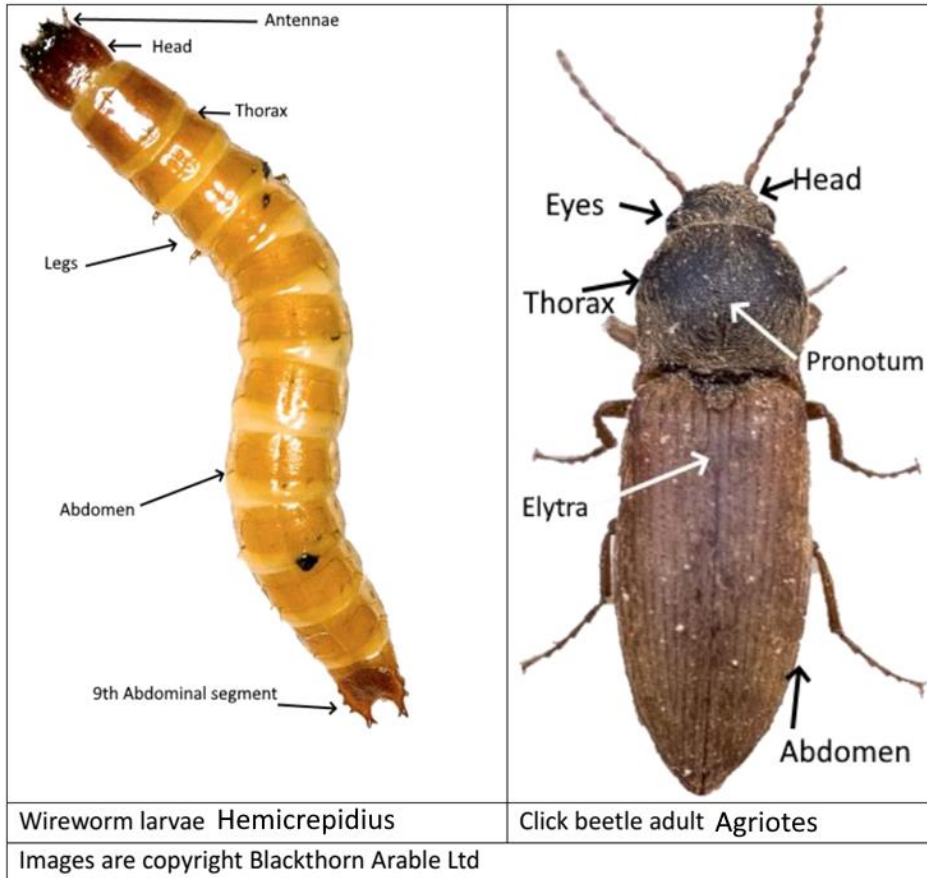


Agrypnus

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Click beetle life stages



4 YEARS?

<12 months

2-3 weeks

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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.

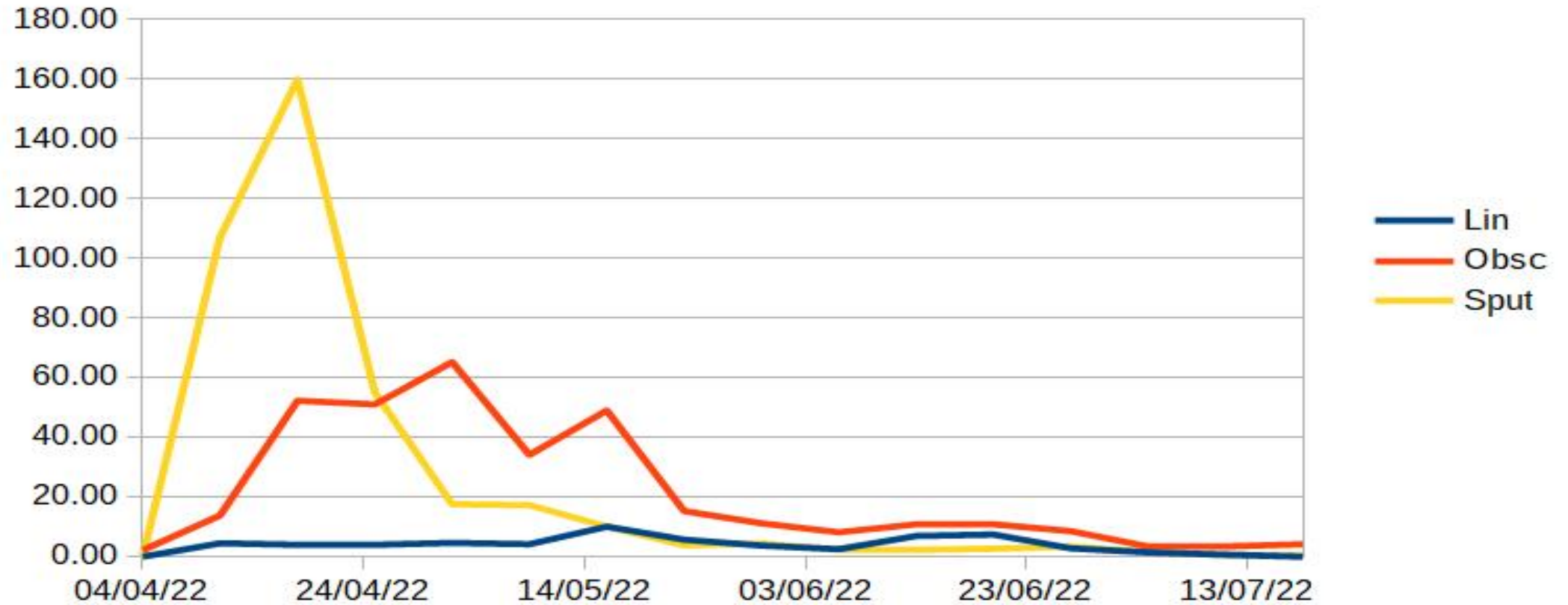
| Development cycle | <i>A. obscurus</i> | <i>A. lineatus</i> | <i>A. sputator</i> |
|-------------------|--------------------|--------------------|--------------------|
| 3 years | 47 % | 58 % | 61 % |
| 4 years | 35 % | 17 % | 28 % |
| 5 years | 18 % | 25 % | 11 % |

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



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 |

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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?

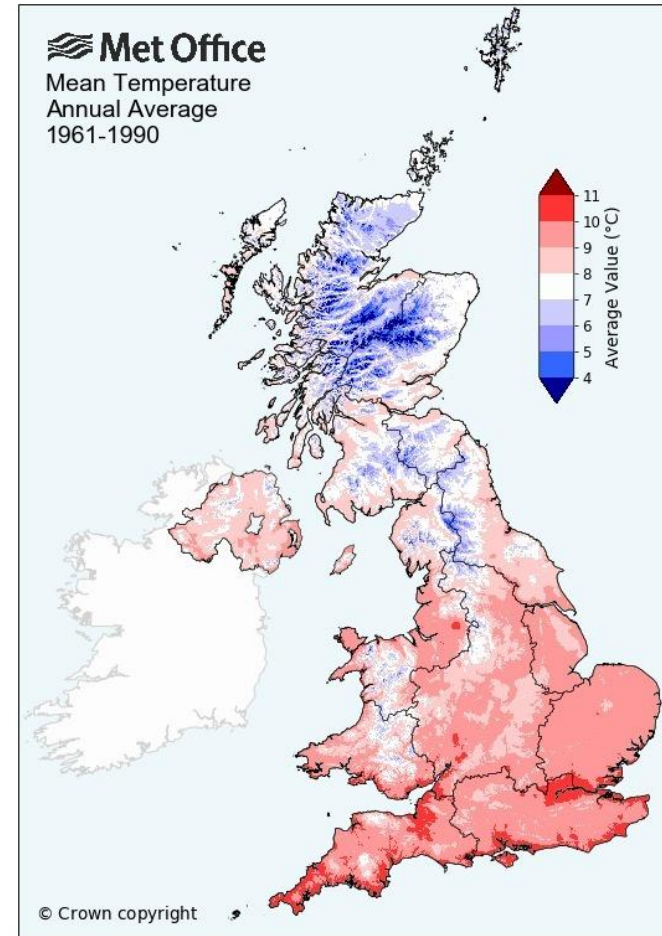
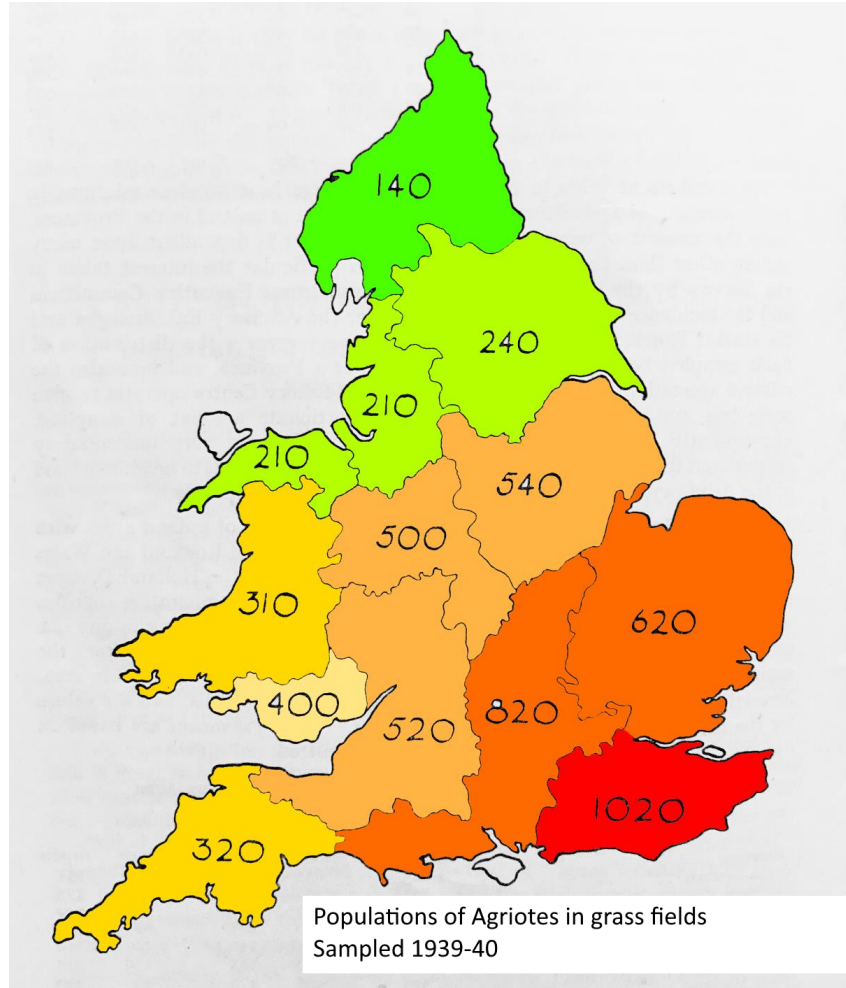


Click beetles: Adult activity

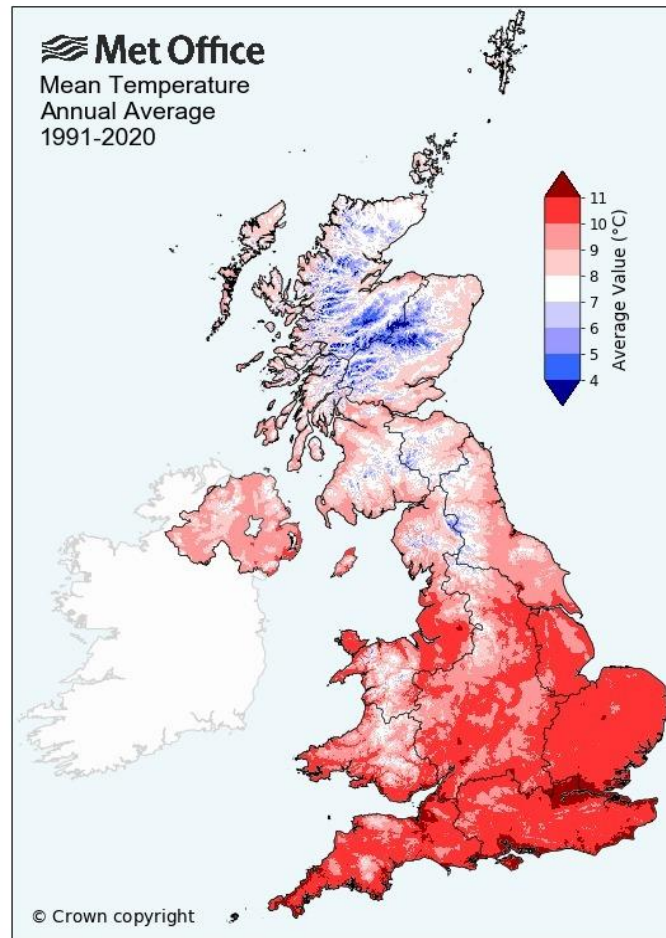
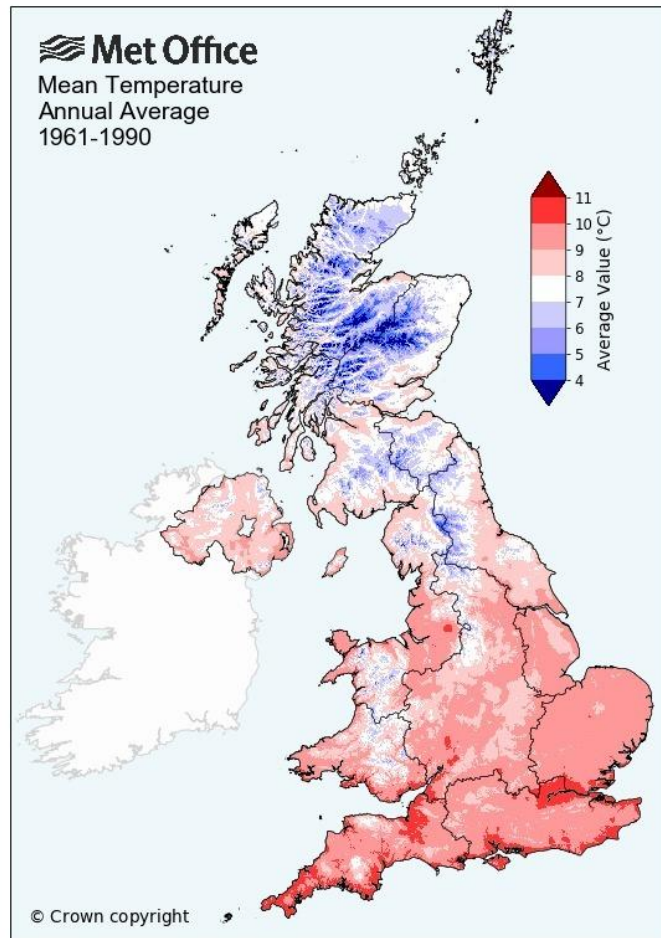
- Previous experience was not good.
- Poor correlation between adult and larval abundance in sites
- It was tried in the UK 20 years ago but did not work well.
- **We now are aware that:**
 - No link between *Agriotes lineatus* adults and larvae
 - *A. obscurus* and *A. sputator* better fit, but still 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



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 |
| 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 | |



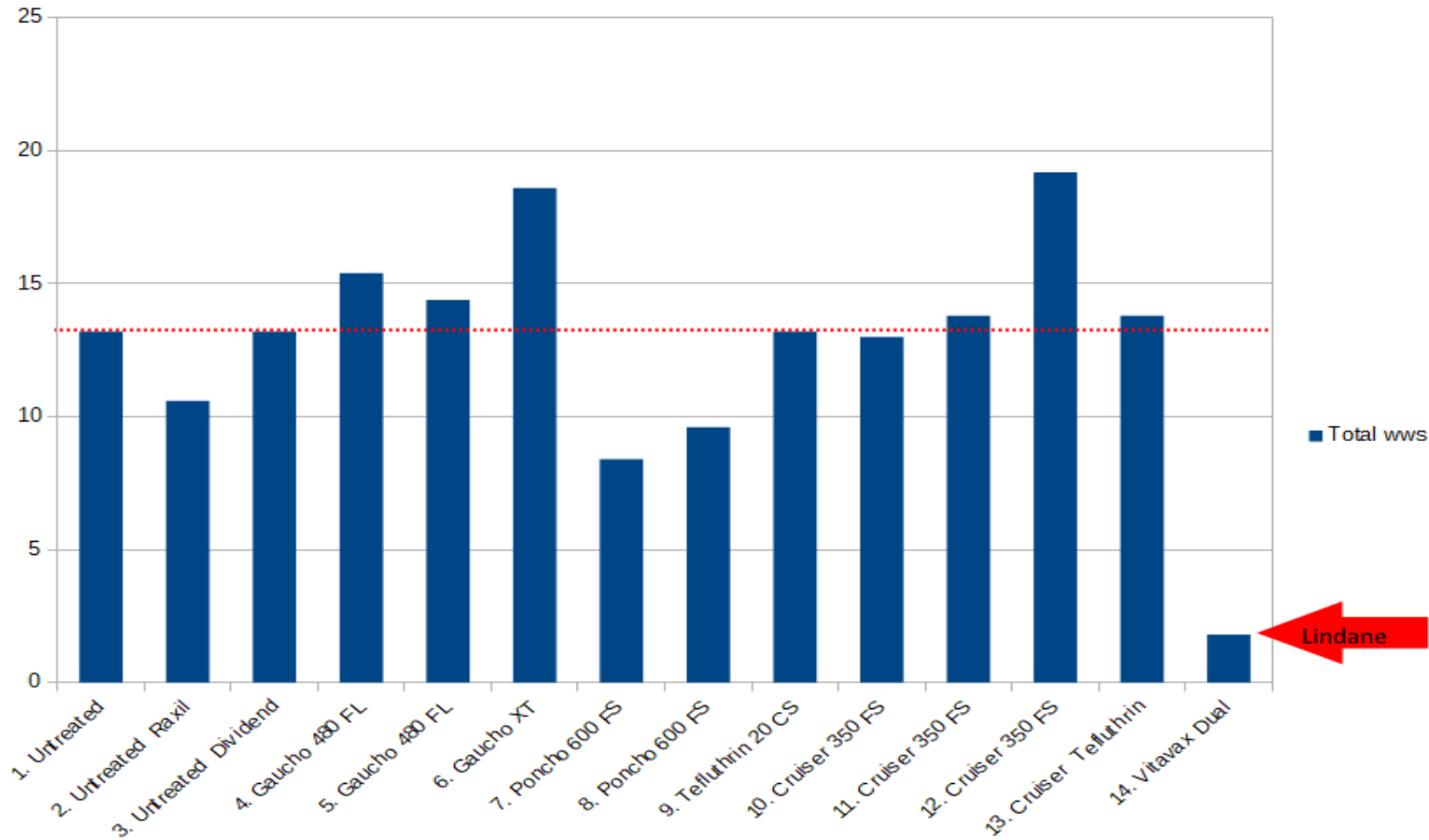
Populations and seed treatments

- 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,¹ 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



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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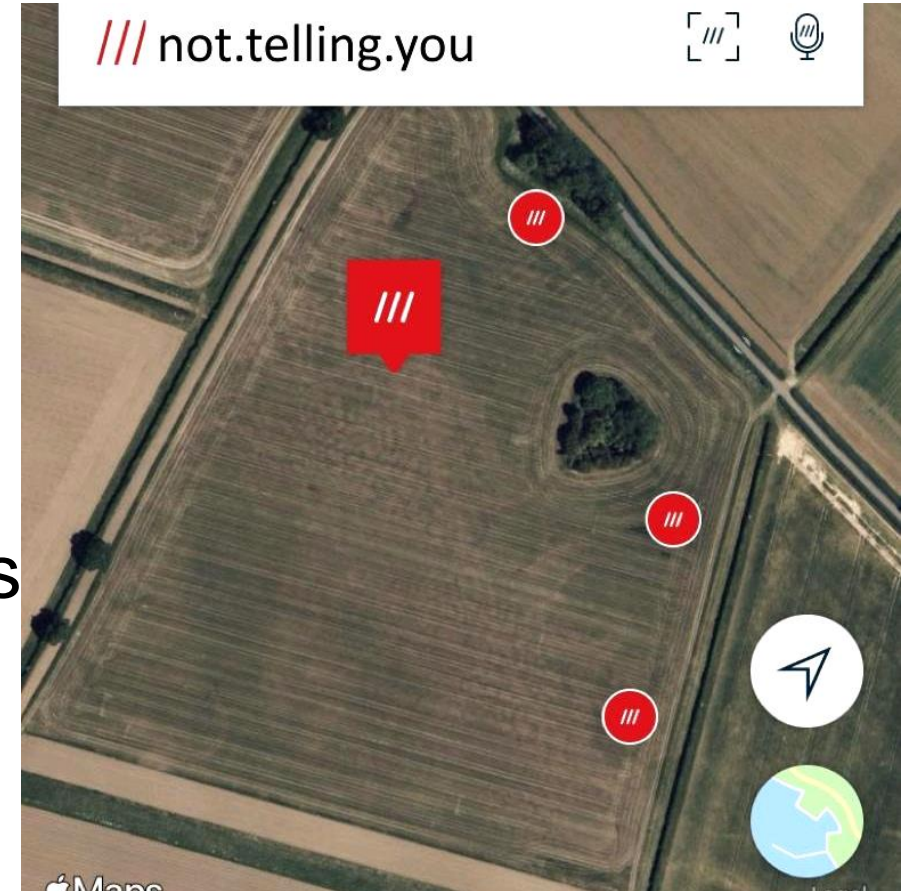



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Bait trap work in 2022

- 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

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

<55M>

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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




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