Thresholds, risks and realities – lessons from the past to inform the future?

Dr Bill Parker
Head of Technical Programmes
AHDB
Where are we with IPM implementation?

- To carry out research on pest management methods is one thing, to get the results **applied in the field by commercial growers** is quite another.
  - Just doing the research is not enough

- This is illustrated by the **relatively low number of pest management methods actually used by growers** in their regular cropping practice when compared with the number of pest management methods which are potentially useful.
  - Much research has been done, relatively little of it has been applied in practice.

This was 1985

Can we measure if we have moved on?

2000: Finch & Collier – QUALITATIVE?

- Improvements in insecticide application, supervised control, and pest forecasting systems have helped to reduce the amount of insecticides required to control vegetable pests.
- By growing plants that are partially resistant to certain major pests, it is now possible to apply even less insecticide than the dose recommended for the crop.
- In crops where only small amounts of insecticides are applied, natural predators should prevent large increases in pest insect populations.

Finch, S & Collier, R 2000. Integrated pest management in field vegetable crops in northern Europe – with focus on two key pests. Crop Protection 19: 817-824

2019: Creissen et al. - QUANTITATIVE

- A significant deficit exists in the ability to practically monitor and measure IPM adoption across arable farms.
- Established a universal metric for quantifying adoption of IPM in temperate arable farming.
- Survey results: all farmers had adopted IPM to some extent (mean score of 65/100), but only 13 of 225 farmers (5.8%) had adopted more than 85% of what is theoretically possible.

Creissen et al., 2019 Measuring the unmeasurable? A method to quantify adoption of integrated pest management practices in temperate arable farming systems. Pest Management Science 75: 3144-3152.
UK Insecticide usage: 1990 – 2016 (all crops)

Source: Official Pesticide Usage Survey data
Thresholds – a key tool that needs metrics

• Economic Injury Level (EIL):
  - The smallest number of pests (amount of injury) that will cause yield losses equal to the pest management costs.

• Economic (action) threshold (ET):
  - The pest density at which management action should be taken to prevent an increasing pest population from reaching the EIL.

• Establishing an ET is hard work:
  - It incorporates the EIL.
  - Need to understand pest population dynamics & relationship with yield loss & crop phenology in the specific crop.
  - Practical aspects of management tactics all have to be considered when establishing ETs.
Threshold concepts in practice

- Low population year
- High population year
- Beneficials (high year)
- High population - treated

Economic Injury Level (EIL)
Economic (action) Threshold

Insects per measurement unit
Fixed-precision sequential sampling plans: Supervised Control of Brussels sprouts pests

Threshold: 10% plants infested

Threshold: 50% plants infested

Accumulated number of infested plants

Accumulated number of plants sampled

Treat

No decision

Don’t treat

Treat

No decision

Don’t treat

NB: You can’t eliminate mistakes entirely: Type I error: False positive; Type II error: False negative
..and the ‘where’ - spatial distribution?

- How are the pests distributed and does this change with time?
  - Aggregated/random?
  - Edge effects?
- Taylor’s Power Law
- SADIE
- Other geostats
Thresholds – a complex & risky business

- Are thresholds always appropriate?
  - Yield vs quality?
  - Crop survival vs acceptable/recoverable damage
  - Virus transmission vs direct damage

- Do we know what we are looking for and why?
  - Eggs, larvae, adults?
  - Economic damage vs population level relationship (ET/EIL)
  - Crop compensation effects?

- Do we know when to look for it?
  - Pre-cropping, in the crop (growth stage?) or post-crop?

- Do we know where to look for it?
  - On the plant, in the soil, in the air?
  - Which part of the field?

- Do we know how best to look/assess?
  - What are the practicalities & economics of sampling and do they stack up?

- Do we understand the risks & trade-offs?
  - What else is affected by controlling this pest (in this way)
  - Effects on beneficials
  - Cost:benefit analysis
Yield loss caused by cereal aphids

• The ‘accepted’ wisdom – a simple action threshold:
  • 5 aphids/ear at flowering (GS 61) *and increasing* (Ken George, 1975/1979).
  • Subsequently adjusted to 66% tillers infested.
  • *Thought* to cause around 20% yield loss....
  • Any relevance to today’s wheat varieties?

• Was/is this good enough?
  • Large differences between potential and achieved profits
  • Value of insecticide treatment varies with time course of infestation
  • Value of forecast depends on its timing & accuracy, the size of the aphid outbreak & its probability of occurrence.
  • ...and BYDV?

Yield loss caused by cabbage stem flea beetle

- **The accepted wisdom – a simple action threshold:**
  - NB – there is/was a model for predicting egg hatch
  - 3-5 larvae plant in the late autumn – plant dissection
  - Subsequently adjusted to a measure of petiole scarring - visual
  - **Any relevance to today?**

- **Larval damage? We should be so lucky!**
  - The timing of adult invasion varies considerably from year to year, being influenced mainly by temperature.
  - Early-germinating crops tend to be invaded earlier than later-germinating ones.

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Currant-lettuce aphid & Lettuce root aphid

• Quality & yield....but zero tolerance of contamination

• Aphid risk varies through the year
  • Different plantings have different risk levels
  • Different control measures could be applied based on risk

• Forecasting more important than thresholds

Soil sampling for wireworms (on potato)

- Developed in 1940s
  - OK for high populations
  - Very unreliable for low populations
- There is a lot of soil out there!
  - Big sampling issue
  - Ideally needs lab processing
- Reality check!
  - Poor correlation between what you find and subsequent damage levels
- Risks
  - You can miss damaging populations
  - There is no in-crop control
  - Risk assessment requires everything we’ve got
Season-long trapping is **NOT** the best way of doing it

Potato cyst nematodes – timescale, tactics & strategy!
Thresholds – so what have we learned?

- Are thresholds always appropriate?
  - Yield vs quality?
  - Crop survival vs acceptable/recoverable damage
  - Virus transmission vs direct damage

- Do we know what we are looking for and why?
  - Eggs, larvae, adults?
  - Economic damage vs population level relationship (ET/EIL)

- Do we know when to look for it?
  - Growth stage?
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No: depends on the type of pest/crop relationship, what level of control is required etc etc.

Yes - but: practicalities may mean that you need to measure a ‘proxy’; hard to figure out the ET/EIL.

Yes: but could be improved a lot for some pest/crop combinations

Depends: on the plant – generally yes. In the field – sometimes not obvious, particularly soil pests.

No: much work done on sampling strategies but remain a fundamental practical stumbling block.

Up to a point: this is the ‘I’ in IPM but the complete integration of pest, disease and weed control requires much more attention.
So do we have decent thresholds for UK arable pests?

- **1986: Internal review by ADAS Entomology**
  - Most thresholds either have no published scientific evidence to support them or are based on old, unpublished data.

- **2017 (30 years on): Ramsden et al., (2017)**
  - Most current economic thresholds for pests of arable crops are not based on published evidence.
  - Few account for the ability of crops to tolerate pest damage, or the amount, or type of crop damage that pests can cause.
  - Many of the methods of pest assessment are impractical and do not guarantee sufficiently accurate estimates of pest abundance.

Realities

- Control of foliar insect pests on major arable crops has been too cheap to justify the use of thresholds as a decision-making tool.
  - A low-risk approach has been widespread though not universal
  - The consequences have been serious – but have taken time to show.

- Soil pests are a somewhat different story, but problems remain
  - The higher cost of control has justified more focus on risk assessment.

- Sampling time/cost has been (and probably remains) the biggest single barrier.
  - The practicality/accuracy of traditional sampling methods has not been good enough.

- Developing robust, dynamic thresholds that reflect a genuine cost:benefit analysis is difficult and complex.
  - This has been under-researched and under-funded over many years – but largely because the pests were (until recently) easily & cheaply controlled.
Risk: how much would you take?

Risk ‘appetite’ will vary with:

- Crop type – yield or quality
- Likely value of crop
- Perceptions of farmer/grower
- Perceptions of agronomist
- ‘Efficacy or otherwise of control options
- The extent to which controls are curative
- Everyone will be different

How do we mitigate the risk?
So where is the future?

• Need to take what we have learned
  • But apply it differently

• Judging risk is a combination of experience and data
  • On-farm ‘experience’ needs to be measured, pooled and analysed
  • ‘Big data’ analytics will be required

• Data, data everywhere but what is really useful?
  • Where are we data poor where being data rich would enable a better decision/risk calculation?

• Farmers, growers & agronomists must have confidence
  • Data sharing is the way forward but issues of ownership, trust and commercial sensitivity need to be resolved.
  • Who does the analysis?

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Another lesson from history?

• Implementation of almost everything in commercial growing depends on cooperation between the researcher, the agronomist and the progressive farmer/grower.

• The researcher must respect the risks taken by the agronomist — the agronomist carries the risk of failure after all.

• New methods must be technically sound and feasible for the farmer/grower i.e. as simple and short as possible. Possibly less critical if benefits are large.

• Cost:benefit analysis is required

• Growers/Farmers will be increasingly seen as ‘progressive’ if they reduce pesticide use