A Review of Progress in Integrated Weed Management

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History

- Integrated Weed Management (IWM) has long been a mainstay of the Annual Weed Reviews.
- A glimpse back through earlier proceedings…

Year	Discussion area
2000	Impact of alternative drilling techniques on weed management
2007	Planning effective weed control across the whole rotation
2008	Innovative physical weed control for horticultural crops
2010	A review of the field performance of 21 (!) new herbicides introduced since 2001; Integrated annual grass weed control through enhanced use of cultural control techniques

More recently

- Although not specifically focused on IWM, the 2017 Annual Review very much focused on “Alternatives for weed control.”
- From an arable perspective, this Review looked at the results from a long-term project targeting black-grass reduction via rotations, cultivations and drilling dates.
- In amenity, the Thanet Project was presented which evaluated thermal and mechanical techniques in comparison to conventional herbicide programmes for hard surface amenity weed control.
- The day finished off with a review and debate on a wide range of new and novel technologies including thermal and electric weeding, use of small robots spot treating, guided inter-row weeders and spot sprayers.

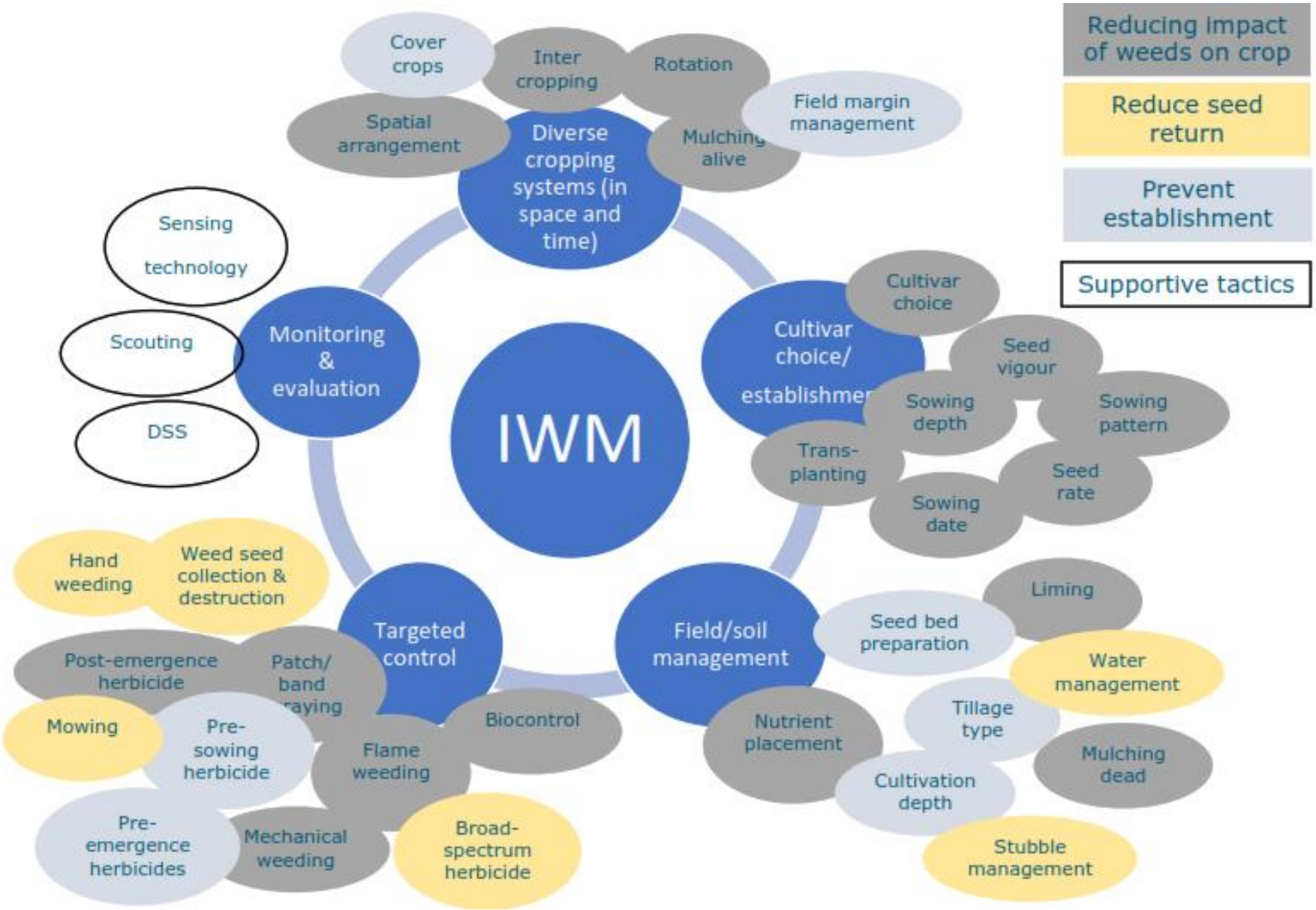
IWMPRAISE

2019

- ‘IWMPraise’ – **I**ntegrated **W**eed **M**anagement: **PRA**ctical **I**mplementation and **S**olutions for **E**urope.
- Pan-European project started in 2017
- Objectives:
  - Barriers to uptake of IWM
  - Develop and enhance the toolbox of validated IWM techniques/practices
  - Design, demonstrate and assessment performance of IWM tools
  - Knowledge exchange/dissemination
- Farmer surveys helped to set a very useful baseline regarding the adoption of all the various weed control tools available.

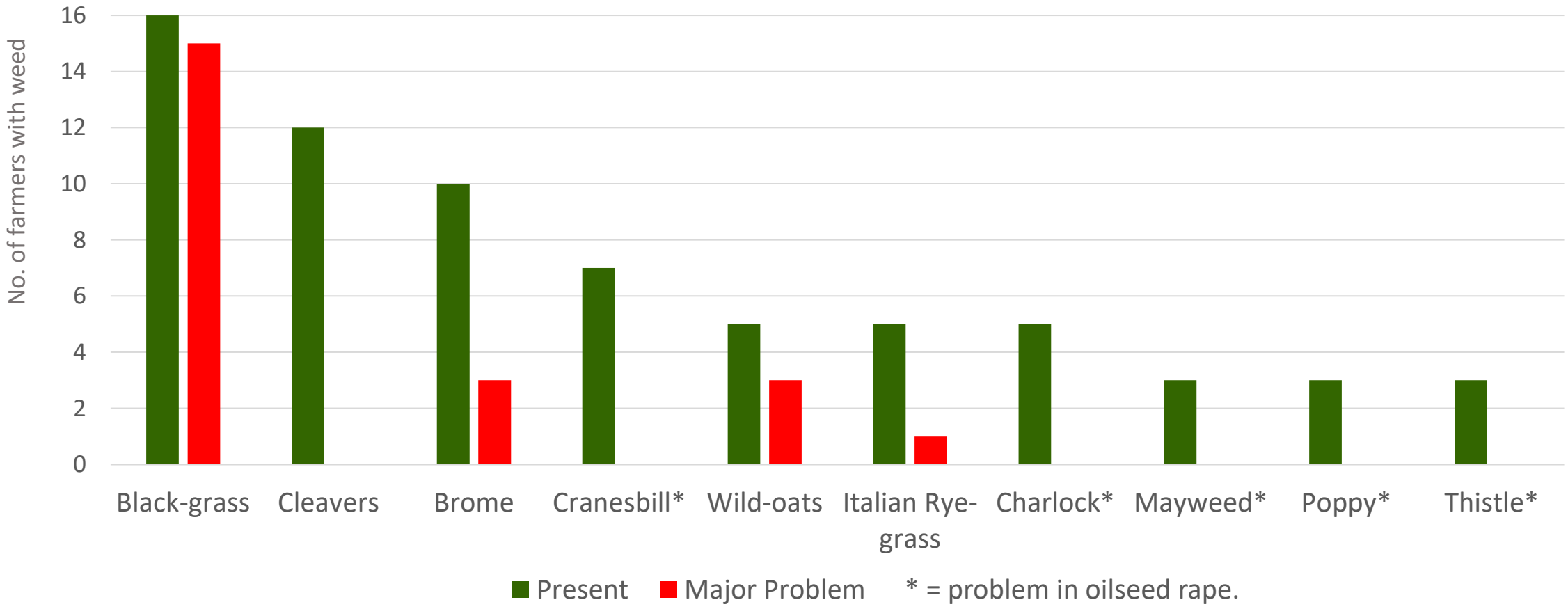
More info at https://iwmpraise.eu

IWM Toolbox was at the heart of the project



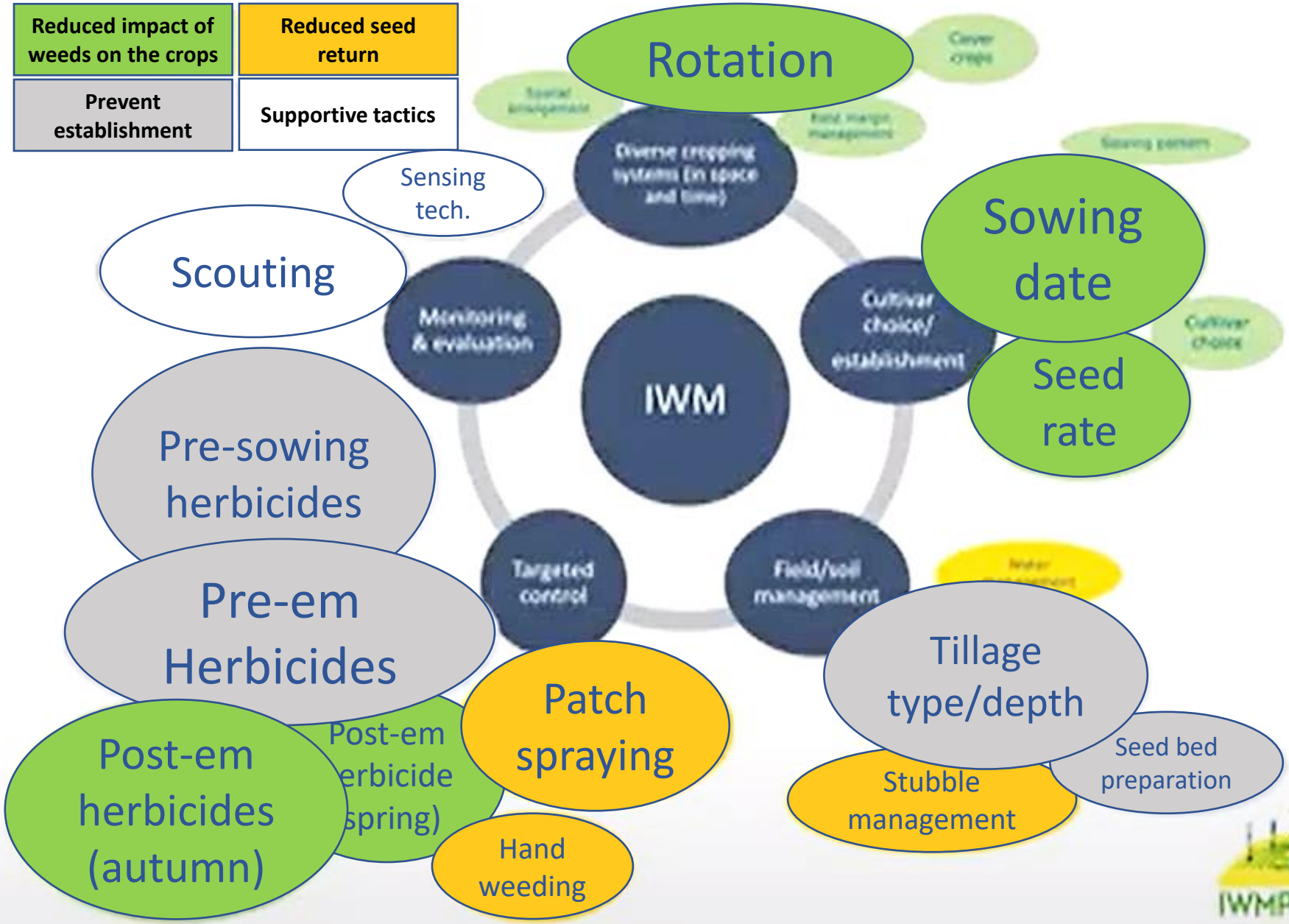
ROTHAMSTED RESEARCH

Key weed problems for arable farmers in England



N = 16; All weeds mentioned 3 or more times

Arable farmer survey revealed the level of adoption in England



Summary

From the Work Package reviewing Arable Practice in England:

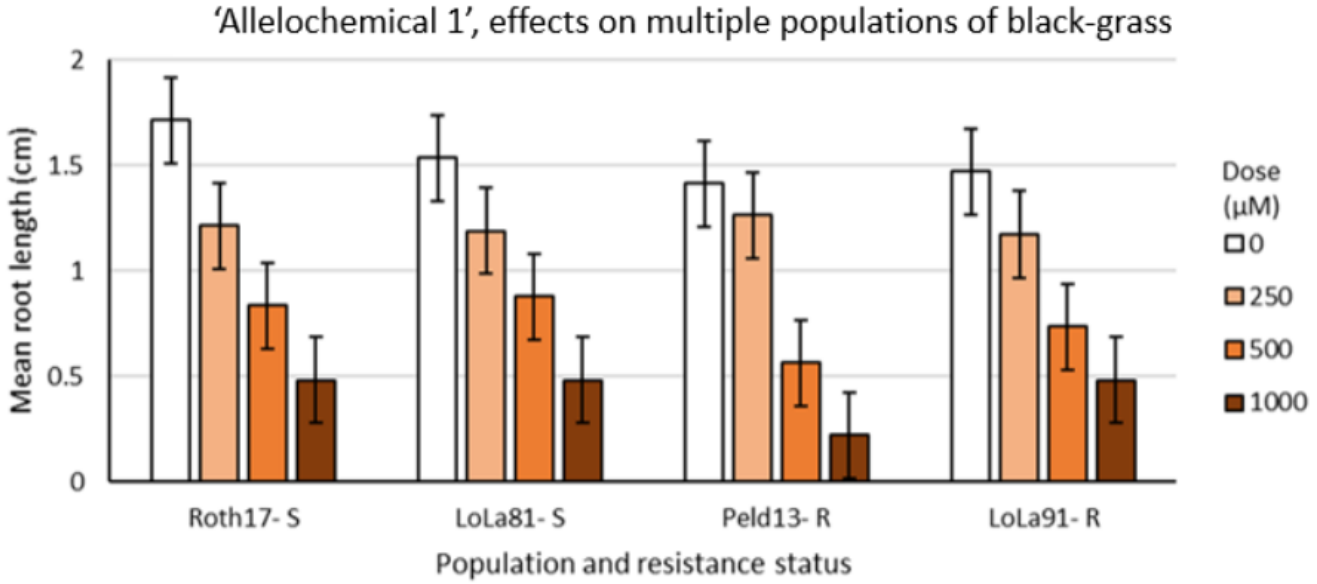
“Diversity/flexibility is key to sustainable weed control”

- ✓ Rotations/cropping ← *as diverse as possible*
- ✓ Drilling dates ← *delay drilling; spring drilling*
- ✓ Cultivations ← *diverse range/depth; whatever works on your soil!*
- ✓ Herbicides ← *lots of different Modes of Action via diverse cropping*
- ✓ Monitoring ← *Key to success! This is really important.*

More info at https://iwmpraise.eu

Alleopathic Compounds for Black-grass control

- Work at Rothamsted Research by Darwin Hickman looked at wheat root exudates for control of black-grass *Alopercurus myosuroides*.
- Two potential ‘allelochemical’ candidates were identified which significantly reduced black-grass root growth.
- Natural levels were too low however at above-natural concentrations, these compounds are inhibitory to black-grass, but not wheat root growth; they may therefore have applicability for weed management.



Natural Enemies against Exotic Weeds

- Invasive species cost the UK £Ms every year!
- CABI specialise in finding natural enemies for invasive alien weeds by visiting the species natural range and identifying species which may eat (insects) or infect (fungi) the plants
- They are having slow but steady success controlling alien invasive weeds in the UK

Species	Natural enemy selected	Latest update
Fairy fern or floating water fern (*Azolla filiculoides*)	*Stenopelmus rufinasus,* a 2mm long weevil	Commercially available and proving successful
Japanese Knotweed (*Fallopia japonica*)	*Aphalara itadori*, a 2mm long psyllid Knotweed Leafspot, *Mycosphaerella polygoni-cuspidati*	Psyllids have been released but limited success due to climate. Proof of concept work for this mycoherbicide
Himalayan Balsam (*Impatiens glandulifera*)	*Puccinia komarovii* var. *glanduliferae*, a leaf rust.	Rust showing adaption to UK conditions and spreading, however multiple strains of rust are required for UK to ensure widespread control.
Australian Swamp Stonecrop *Crassula helmsii*	*Aculus crassulae*, a mite new to science	Challenging to work with due to tiny size. First release late 2018 with success overwintering. Monitoring continues.
Floating Pennywort (Hydrocotyle ranunculoides)	*Listronotus elongatus*, a 6mm long weevil from Argentina	Coordinated release began this summer (2022).

IWM for Glyphosate Resistance Management

- The *Minimising the Risk of Glyphosate Resistance Project* provided key stewardship advice/guidance for farmers and advisors.
- Focused on 4 key elements, which are easily achievable.
- *Use alternatives* stresses the important of integrating cultural techniques and as alternative herbicdes.
- *Monitor success* highlights the importance of removing survivors, for example, using hand rogueing.

Sensing for Targeted Weed Control

- Plant sensing has along history going back to the 1960s.
- Optical sensors are attractive to crop/weed applications as they don’t need physical contact.
- Sensors can be coupled to mechanisms to allow for real time treatment.
- Commercially available as the Weedseeker and Weed IT for amenity use – sensors detecting weeds on pavements which are then spot sprayed – and as guided hoes, such as Garford’s machine.
- Ongoing research aims to link hyperspectral reflectance with leaf shape and texture derived from images to train computers to distinguish between plant types.

Weed dynamics/carbon implications of Regenerative Agriculture

2020

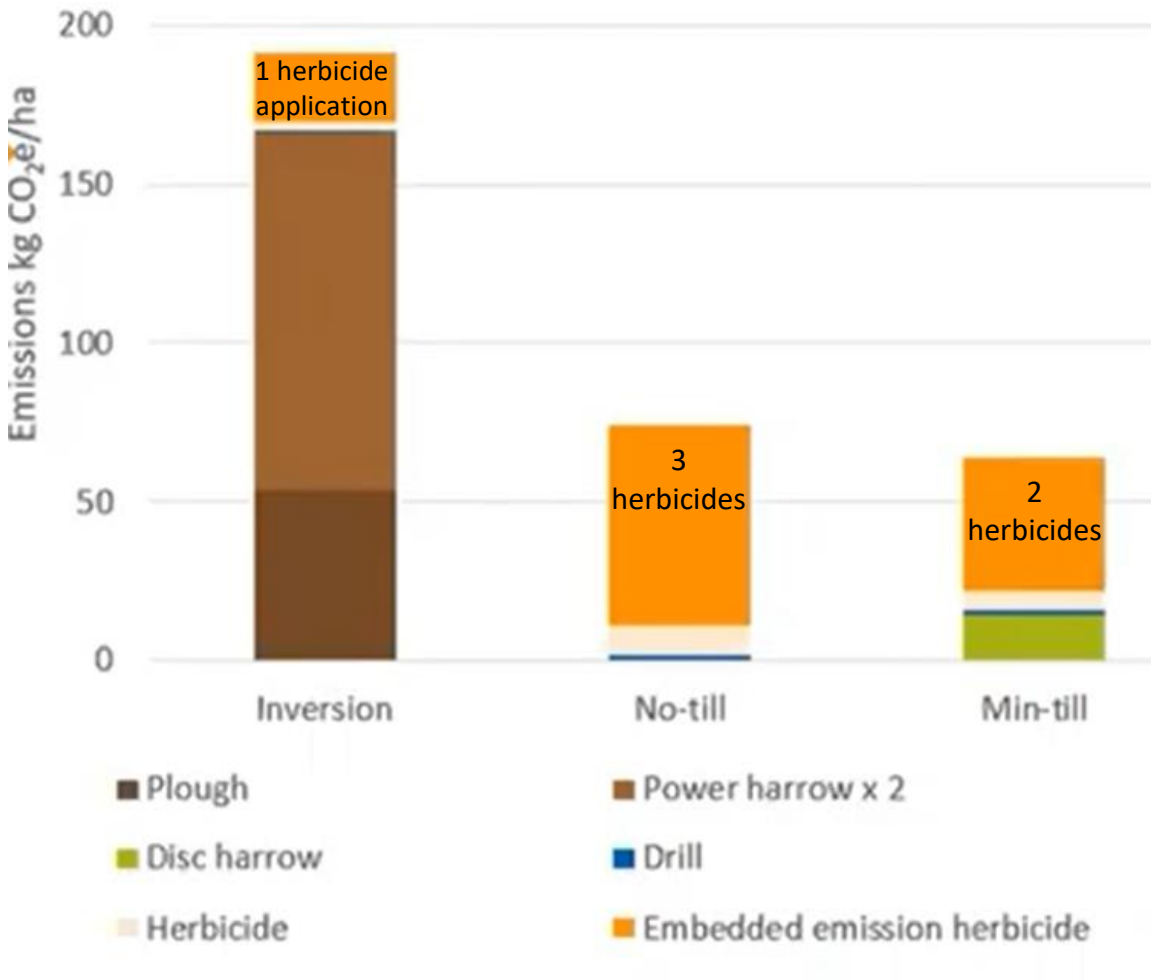
- **Why adopt Regenerative Agriculture?**
  - The belief that the current system is broken
- **The Methods?**
  - Zero tillage
  - Diverse cropping and rotation, including herbal grass leys
  - Overwintered cover crops and companion crops
  - Integration of livestock – fastest single way to build soil carbon!
  - Also Zero insecticides, Zero seed dressings, no wormers for cattle, composted manure, improved habitat creation
- **The Outcomes?**
  - Improved soil carbon
  - Reduction in reliance on pre- and post-em herbicide use
  - Reduction in black-grass however bromes, thistles, sowthistles and self-seeded ash trees(!) are increasing
  - Reduced synthetic N by 35%; No P & K applied for 10 years

Groundswell

Carbon Impact of Weed Management

- Soil inversion e.g. via ploughing, is the most Carbon intensive part of crop establishment and weed control.
- Even if herbicides are factored in the reduced tillage approaches, whether no-till or min-till, still have less than half the Carbon emissions of full inversion tillage.
- Soil inversion resulted in Carbon emissions due to burning fuel and also as a result of soil carbon exposure to oxygen.
- On the plus side, soil inversion reduces the need for herbicides

- What is the ultimate target?
  - Management of carbon emissions?
  - Maintenance of soil carbon?
  - Reduction in pesticide use?



SCEPTREPLUS

Sustainable Plant Protection Products for use in Horticulture

Project ran over 4 years: 2017-21

- Over 250 products evaluated
  - 205 conventional products
  - 45 biologicals/biopesticides
- In over 50 crops

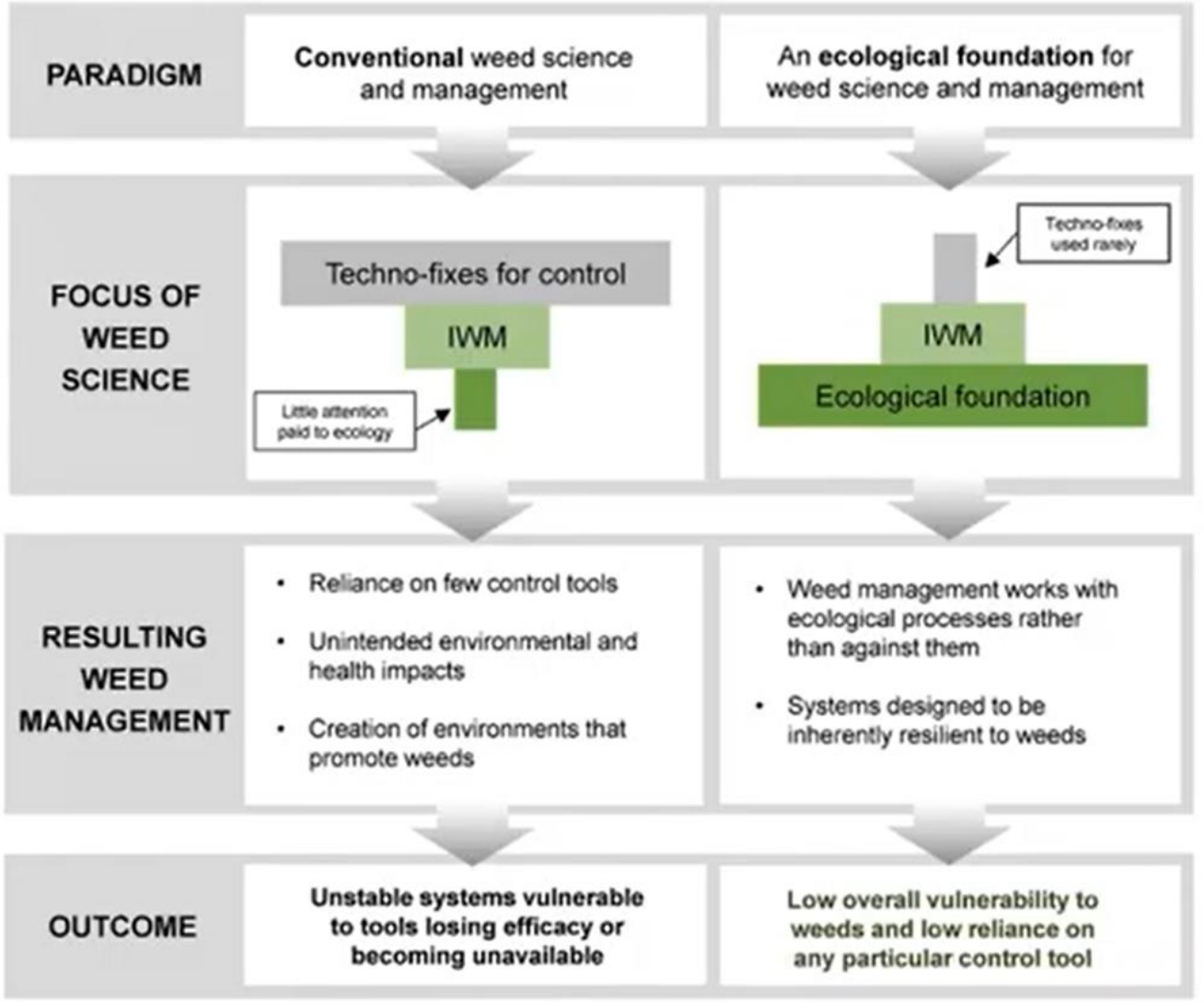
For herbicides…

- 17 trials with 26 different crop targets
- EAMU output:
  9 herbicides in 23 crops/crop groups

Product	Crop
Devrinol	Herbs, spinach
Dual Gold	Sweetcorn
Emerger	Garlic, onion, shallot, caraway, dill, parsley, carrot, parsnip, celery
Flexidor	Carrot, horseradish, parsnip
Gamit	Carrots
Hurricane	Carrots
Metobromuron	Ornamental bulbs
Venzar 500SC	Outdoor leafy veg + fresh herbs
Wing P	Courgette, squash, pumpkin, sweetcorn

Is IWM the destination or the way point?

- Is there a need for a paradigm shift from conventional weed science and management to an ecological foundation for weed science and management?
- Is the current conventional weed management approach self perpetuating and reliant on new 'techno-fixes' to deliver effective weed control?
- Should we pause and rethink the approach developing a position which works with ecological processes rather than against it?
- Perhaps we need to return to the drawing board!



Ref: MacLaren *et al*. *Agronomy for sustainable development*, **40**(4), 29

Weed control in All-Arable Organic Farming (Stockless) Systems

- Fertility restoring phases alternated with cash cropping
  - Grass/Red clover → W.Wheat → W.Oats→ W.Beans → S.Oats/Grass/Red clover undersown → cut & mulched for 1 year
- In a stockless system the Mower/Topper replaces the stock!
- Cutting & mulching prevents seeding during fertility building
- Sequential stale seedbeds managed via cultivation
- Delayed drilling of winter sown crops
- Double seed rates for competitive crops
- Mechanical inter-row weeding in spring if conditions allow
  - Only effective when the soil surface is dry
- Hand rogueing e.g. docks and wild-oats
- Crop destruction – the ultimate solution if the weed burden gets too great!

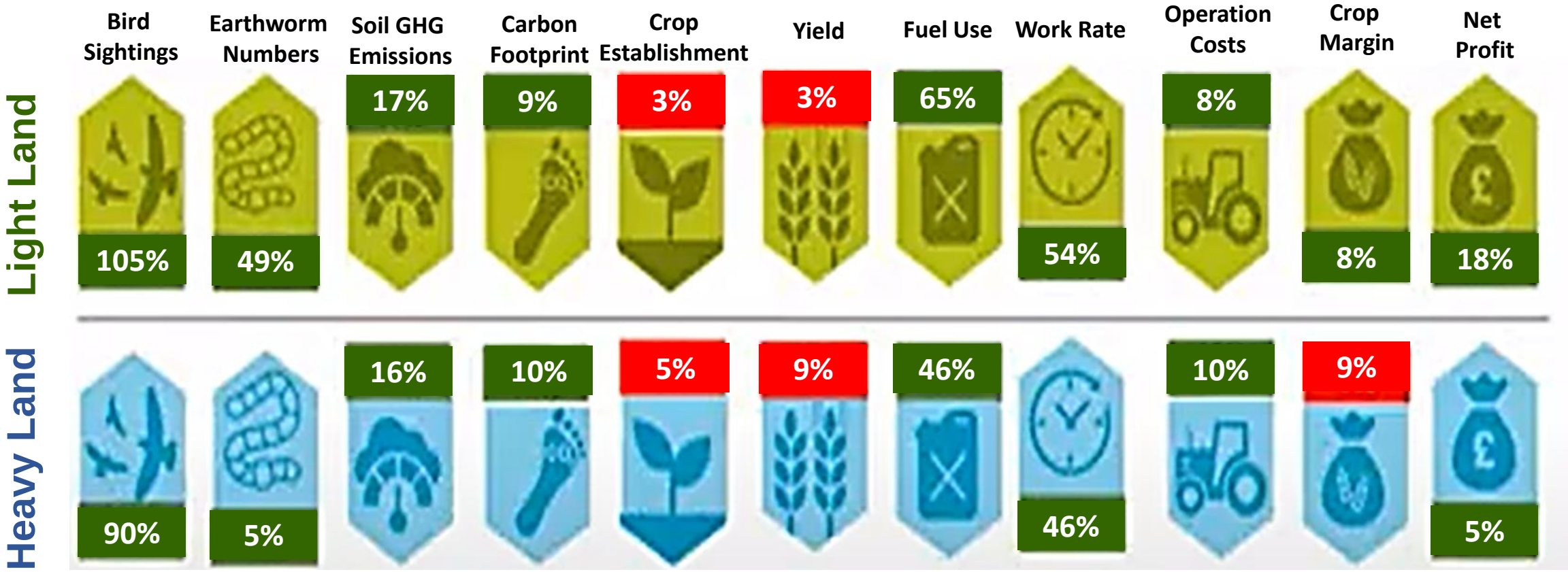
2021

Lessons from Organic farming

Game & Wildlife CONSERVATION TRUST

Sustainable systems vs. conventional systems: GWCT experience

- Results from the European Conservation Agriculture Project comparing sustainable direct drill-based system with plough based conventional system



Integrated Weed Management for Japanese Knotweed

Prevention:

Possible to prevent from arriving on site in the first place - limit opportunities for fly-tipping, biosecurity etc.

Detection:

Early detection/monitoring can isolate young plants and effectively treat at an early age.

Physical/Mechanical Control:

Knotweed may be excavated either fully or partially (if feasible) or treated using a physical process (screening, heat etc.) if feasible. A robust root barrier can be used. Such approaches have high cost/carbon footprint.

Electric weeding is in its infancy - delivers limited control with high cost/carbon footprint.

Biocontrol:

No effective biological control commercially available yet.

Chemical:

Limited herbicides available, mainly focused on glyphosate, and takes multiple years of treatment to achieve control/eradication. No one-shot solution!

Summary

- IWM has been a regular and important feature of the Annual Weed Reviews, and for the past 4 years has been the key focus.
- Review audiences have seen that IWM goes beyond arable to encompass a whole host of horticultural and amenity situations.
- From examination of the current situations in arable and amenity through to specific projects evaluating weed control techniques and products, the Reviews have discussed a wide and varied range of IWM subjects and activities.
- Without doubt, IWM will continue to an important and relevant focus for the BCPC Expert Group on Weeds.

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