A Review of Progress in Integrated Weed Management

Dr Henry Creissen
Scotland’s Rural College (SRUC), Edinburgh
• Integrated Weed Management (IWM) has long been a mainstay of the Annual Weed Reviews.
• A glimpse back through earlier proceedings...

<table>
<thead>
<tr>
<th>Year</th>
<th>Discussion area</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>Impact of alternative drilling techniques on weed management</td>
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<tr>
<td>2007</td>
<td>Planning effective weed control across the whole rotation</td>
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<tr>
<td>2008</td>
<td>Innovative physical weed control for horticultural crops</td>
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<tr>
<td>2010</td>
<td>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</td>
</tr>
</tbody>
</table>
• 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

• ‘IWMPraise’ – Integrated Weed Management: PRActical Implementation and Solutions for Europe.

• 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
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

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

• *Monitor success* highlights the importance of removing survivors, for example, using hand rogueing.

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**Prevent survivors**
- Repeat application to surviving plants presents the highest risk

**Monitor success**
- Consult your agronomist or supplier
- Remove survivors to prevent spread
- Test seed samples of survivors

**Maximise efficacy**
- Use the right dose rate for the target weed on actively growing plants
- Reduced rates increase risk of reduced efficacy

**Use alternatives**
- Use cultivation or other non-chemical control when practical
- Use other herbicides in sequence (or mixture only if recommended)
Sensing for Targeted Weed Control

- Plant sensing has a long 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

• 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
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?
SCEPTRE PLUS
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

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

<table>
<thead>
<tr>
<th>Metric</th>
<th>Light Land</th>
<th>Heavy Land</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bird Sightings</td>
<td>105%</td>
<td>90%</td>
</tr>
<tr>
<td>Earthworm Numbers</td>
<td>49%</td>
<td>5%</td>
</tr>
<tr>
<td>Soil GHG Emissions</td>
<td>17%</td>
<td>16%</td>
</tr>
<tr>
<td>Carbon Footprint</td>
<td>9%</td>
<td>10%</td>
</tr>
<tr>
<td>Crop Establishment</td>
<td>3%</td>
<td>5%</td>
</tr>
<tr>
<td>Yield</td>
<td>3%</td>
<td>9%</td>
</tr>
<tr>
<td>Fuel Use</td>
<td>65%</td>
<td>46%</td>
</tr>
<tr>
<td>Work Rate</td>
<td>54%</td>
<td>46%</td>
</tr>
<tr>
<td>Operation Costs</td>
<td>8%</td>
<td>10%</td>
</tr>
<tr>
<td>Crop Margin</td>
<td>8%</td>
<td>9%</td>
</tr>
<tr>
<td>Net Profit</td>
<td>18%</td>
<td>5%</td>
</tr>
</tbody>
</table>
# 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.
BCPC’s Expert Group on Weeds would like to thank our sponsors

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