Factors affecting weed control in arable crops

Dr Nicola Cannon
SEEDS

SPREAD

RHIZOMES

NUTRIENTS

YIELD

DIVERSITY

HOES

WIND

LEGISLATION

COMPETITION

ADAPTATION

KNOWLEDGE

QUALITY

LIGHT

SMALL

SMALLER

BIOLOGY

DRILLING

HARROWS

RHIZOMES

SEEDBANK

MULCHES

GRAZING

RESISTANCE

ENVIRONMENTAL

WEAR

DRILLS

BIOLOGICAL

FLOWERS

GERMINATION

ROOTS

WATER
Techniques for weed control

1. Understanding weed biology
2. Physical removal
3. Chemical options (if available)
Understanding weeds

- **Control**
  - Timing
  - No. of treatments

- **Evaluation**
  - Product choice
  - Monitoring
  - Thresholds
  - Field location and history

- **Prevention**
  - Drilling dates
  - Soil health
  - Rotations
  - Competitive varieties
  - Cultivations
Leaves are broad, triangular and toothed on short stems
Can grow at low temperatures and have 2 generations a year
Grows in winter & spring sown crops
Sprawling growth habit
Pretty blue flowers on a long stem
Approaches to weed Control

Broad-spectrum - weeding across the entire area

Inter-row - weed machinery is focused between the crop rows

Intra-row - weeding is carried out in the crop row itself

Patches - specific patches are targeted by hand or machine
Above ground weeding

• Requires physical difference
  – Need to have weeds that are taller than the crops

• Weed wipers
  – Electric
  – Glyphosate????
**DESCRIPTION**
Ubiquitek Touch Pro is our award-winning professional hand-held weed killer, used in a range of sectors.

**TECHNOLOGY**
Touch Pro uses electrodes to kill weeds from the roots, ensuring minimal water loss and preventing damage to the surrounding plants or soil.

**EFFECTIVENESS**
Touch Pro is effective on all types of weeds, including perennial, annual, annual and invasive weeds, including dandelions.

**SECTORS**
Touch Pro is designed for the Forestry and Pasture sectors and is ideal for gardens, gardens and agriculture with no risk or harm to grass and for ongoing weed management.

**SUSTAINABLE**
Organic, environmentally friendly, residue and chemical-free.

**EFFECTIVE**
Safe and easy to use, ideal for the control of weeds developing without

**VERSATILE**
Ideal for a wide range of weeds, substrates and weather conditions.

**SAFEGUARDED**
Design features ensure operator is safeguarded with no risk to plants or weeds.
The next step for weed control

• The technology is available:
Automated lawn mowers
But this is what I need....
Robotic weeding

http://www.trp.uk.com/carre-farm-machinery/carre-meadow-maintenance/anatis.html
Agricultural challenges in 2017

- Uncertain weather patterns
- Limited supply of labour
- Challenges of soil compaction
- Low resolution of precision farming

LARGER MACHINERY
Small robotic solutions could offer...

- Reduced soil compaction
- Increased yields
- Better imagery
- Improved precision farming
- Swarms of robots
- Improved efficiency
- Increased margins?

[Image of a robotic device in a field](https://agribotics.blogs.lincoln.ac.uk/files/2014/03/cropped-boni_rob.png)
Weed mapping

- Works on the chlorophyll content difference between blackgrass and wheat
- Using RedEdge multispectral sensor
- Processing the results into an orthomosaic, DSM and several different vegetation indices.
But what can be done now....
The effect of oat seed rate on weed development

Nie & Taylor, 1995
Quantifying tools available for weed control

- Crop establishment technique
- Sowing date
- Crop height/variety
- Weed removal
- Sheep grazing
- Undersowing
- Weed seed banks
Varieties

The impact of variety on biomass accumulation (sown 22 Sept)

![Grain field image]
Sowing Date and variety

The impact of variety and sowing date on biomass
Sowing Date and variety

The impact of variety and sowing date on biomass and weeds
The effect of variety and sowing date on weed biomass in June

Maris Widgeon

Hereward

Genesis

Sown 22 sept  Sown 27 Nov
“The Corn Harvest"
Pieter Bruegel the Elder, 1565
Metropolitan Museum of Art, New York
Why the Rht (reduced height) gene was introduced...

- The Green Revolution found that introducing a gene ‘Norin 10’ from Japanese wheat:
  - Decreased plant height leading to:
    - An increased harvest index
    - Stronger plant and lower lodging risk
  - Capable of:
    - Yielding more
    - Responding to higher levels of crop inputs

- Worked by making the plant unresponsive to the plant growth hormone, gibberellin, which normally increases stem height
The impact of dwarfing genes on blackgrass

Table 1. The effects of dwarfing genes on *A. myosuroides* head numbers, whole grain yield and yield components of winter wheat cv. Maris Widgeon.

<table>
<thead>
<tr>
<th></th>
<th>A. myosuroides</th>
<th>Ear No.</th>
<th>Grain No.</th>
<th>TGW (g d.m.)</th>
<th>Yield (t ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Rht</td>
<td>5.7</td>
<td>218</td>
<td>9940</td>
<td>38.1</td>
<td>2.96</td>
</tr>
<tr>
<td>Rht1</td>
<td>21.1</td>
<td>248</td>
<td>13300</td>
<td>33.2</td>
<td>3.59</td>
</tr>
<tr>
<td>Rht2</td>
<td>20.8</td>
<td>243</td>
<td>11300</td>
<td>36.4</td>
<td>3.25</td>
</tr>
<tr>
<td>Rht1+2</td>
<td>30.2</td>
<td>267</td>
<td>14000</td>
<td>30.4</td>
<td>3.30</td>
</tr>
<tr>
<td>S.E.D.</td>
<td>8.18</td>
<td>12.02</td>
<td>954</td>
<td>1.98</td>
<td>0.195</td>
</tr>
</tbody>
</table>
Grazing
The effect of variety and grazing on crop height, weed dry matter and grain yield. Average of 2 sowing dates. 1993-1994

<table>
<thead>
<tr>
<th>Variety</th>
<th>With (+) &amp; without (-) grazing</th>
<th>Crop height (cm)</th>
<th>Weeds (g DM m⁻²)</th>
<th>Grain yield (t ha⁻¹ 85% DM)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>29-Mar</td>
<td>20-Jun</td>
<td>06-Jun</td>
</tr>
<tr>
<td>Maris Widgeon</td>
<td>-</td>
<td>12.5</td>
<td>119.5</td>
<td>105</td>
</tr>
<tr>
<td>Maris Widgeon</td>
<td>+</td>
<td>7.8</td>
<td>112.3</td>
<td>82</td>
</tr>
<tr>
<td>Hereward</td>
<td>-</td>
<td>9.4</td>
<td>82.4</td>
<td>115</td>
</tr>
<tr>
<td>Hereward</td>
<td>+</td>
<td>5.7</td>
<td>79</td>
<td>83</td>
</tr>
<tr>
<td>Genesis</td>
<td>-</td>
<td>8.2</td>
<td>80.3</td>
<td>99</td>
</tr>
<tr>
<td>Genesis</td>
<td>+</td>
<td>5.5</td>
<td>79</td>
<td>91</td>
</tr>
<tr>
<td>s.e.d. (grazing, same variety)</td>
<td></td>
<td>0.73</td>
<td>1.47</td>
<td>11.5</td>
</tr>
<tr>
<td>s.e.d. (variety, same grazing)</td>
<td></td>
<td>0.29</td>
<td>1.43</td>
<td>10.7</td>
</tr>
</tbody>
</table>

Significance levels

- Grazing: * * *** * -
- Variety: *** ** - -
- Grazing X Variety: *** - - -

Gooding et al. 1998
Main findings:
- Ear numbers were average, but low TGW resulting in low yield
- Weeding increased:
  - Ear number
  - Grain yield
  - HFN
- Grazing reduced ear number

<table>
<thead>
<tr>
<th>Weeding</th>
<th>Grazing</th>
<th>Ear Number m⁻²</th>
<th>Yield (t ha⁻¹) 85% DM</th>
<th>TGW (g) DM</th>
<th>Crude protein (%) 85% DM</th>
<th>Hagberg falling number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>243</td>
<td>1.53</td>
<td>31.6</td>
<td>10.18</td>
<td>243</td>
</tr>
<tr>
<td></td>
<td></td>
<td>318</td>
<td>2.00</td>
<td>32.7</td>
<td>10.16</td>
<td>243</td>
</tr>
<tr>
<td></td>
<td></td>
<td>223</td>
<td>1.33</td>
<td>31.4</td>
<td>10.18</td>
<td>238</td>
</tr>
<tr>
<td></td>
<td></td>
<td>231</td>
<td>1.53</td>
<td>31.6</td>
<td>10.21</td>
<td>262</td>
</tr>
</tbody>
</table>

SED(9df) | 25.0 | 0.184 | 1.01 | 0.314 | 8.83 |
SED(same defoliation) | 29.0 | 0.216 | 0.87 | 0.217 | 8.74 |

Cosser et al. 1997

Table 1. *The effect of weeding and defoliation method on grain yield and quality*
Undersowing
Table 1. Effect of undersown legume species on organic spring wheat

<table>
<thead>
<tr>
<th></th>
<th>Plant height (cm)</th>
<th>Ear (numbers m⁻²)</th>
<th>Wheat DM yield (t ha⁻¹)</th>
<th>TGW (g)</th>
<th>Grain yield (t ha⁻¹)</th>
<th>Legumes DM yield (t ha⁻¹) (a)</th>
<th>Weeds DM yield (t ha⁻¹) (b)</th>
<th>Non-wheal DM yields (t ha⁻¹) (a+b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-undersown</td>
<td>81.52a</td>
<td>372a</td>
<td>9.37a</td>
<td>34.73</td>
<td>3.79a</td>
<td>0.130a</td>
<td>0.172</td>
<td>0.307a</td>
</tr>
<tr>
<td>Wheat + WC</td>
<td>81.16a</td>
<td>360a</td>
<td>8.89ab</td>
<td>34.24</td>
<td>3.61ab</td>
<td>0.258b</td>
<td>0.195</td>
<td>0.452ab</td>
</tr>
<tr>
<td>Wheat + BM</td>
<td>80.66ab</td>
<td>335ab</td>
<td>8.52ab</td>
<td>34.36</td>
<td>3.51ab</td>
<td>0.264b</td>
<td>0.226</td>
<td>0.489abc</td>
</tr>
<tr>
<td>Wheat + BT</td>
<td>80.44ab</td>
<td>328ab</td>
<td>7.34bc</td>
<td>33.70</td>
<td>2.92bc</td>
<td>0.272b</td>
<td>0.245</td>
<td>0.517bc</td>
</tr>
<tr>
<td>Wheat + V</td>
<td>79.25b</td>
<td>307bc</td>
<td>7.28bc</td>
<td>33.39</td>
<td>2.84bc</td>
<td>0.293bc</td>
<td>0.278</td>
<td>0.571bc</td>
</tr>
<tr>
<td>Wheat + RC</td>
<td>77.17c</td>
<td>290bc</td>
<td>6.75c</td>
<td>33.64</td>
<td>2.62c</td>
<td>0.298bc</td>
<td>0.265</td>
<td>0.563bc</td>
</tr>
<tr>
<td>Wheat + CC</td>
<td>76.30cd</td>
<td>286bc</td>
<td>6.60c</td>
<td>32.83</td>
<td>2.52c</td>
<td>0.358bc</td>
<td>0.309</td>
<td>0.667c</td>
</tr>
<tr>
<td>Wheat + PC</td>
<td>75.14d</td>
<td>275c</td>
<td>6.26c</td>
<td>32.16</td>
<td>2.27c</td>
<td>0.393c</td>
<td>0.282</td>
<td>0.675c</td>
</tr>
<tr>
<td>SED (53 df)</td>
<td>0.86</td>
<td>24.81</td>
<td>0.862</td>
<td>1.319</td>
<td>0.412</td>
<td>0.058</td>
<td>0.084</td>
<td>0.104</td>
</tr>
</tbody>
</table>

*Significance*  
*** significance $P<0.001$,  
** significance $P<0.01$,  
* significance $P<0.05$, ns non-significant.

Any two mean within columns not sharing common letters differs significantly.
Key findings:

- More weed seeds germinated after early rather than late sown wheat.
- Blackgrass seedlings were much greater in early sown wheat but less so when grazed by sheep in 1995.
- More charlock emerged from plots sown with Maris Widegon (1.70) than Genesis (1.33) or Hereward (0.81).
Crop establishment technique

The effect of crop establishment technique on weed biomass in winter wheat (2011) and spring wheat (2012 & 2013)

Weed biomass kg/ha

- Plough & powerharrow drill
- Minimum tillage
- Direct Drill

Bhaskar et al. 2014
The effect of crop establishment technique on weed biomass in organic winter wheat (2011), spring wheat (2012 and 2013) and with the addition of a single pre drilling Glyphosate spray
The effect of crop establishment technique on weed biomass in winter wheat (2011) and spring wheat (2012-2014) and later with the addition of a single pre drilling glyphosate spray.
### Impact of Nitrogen application

#### Table 3: Analysis of variance for year, tillage and N management effects. Mean values for weed aboveground biomass and spring wheat grain yield parameter

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Early Total Weed DM (t ha(^{-1}))</th>
<th>Midseason Total Weed DM (t ha(^{-1}))</th>
<th>Broadleaf Weed DM (t ha(^{-1}))</th>
<th>Grass Weed DM (t ha(^{-1}))</th>
<th>Total Weed DM (t ha(^{-1})) at harvest</th>
<th>Grain Yield (t ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year (Y)</td>
<td>1</td>
<td>0.0338a</td>
<td>1.438b</td>
<td>1.131b</td>
<td>0.307a</td>
<td>1.140b</td>
<td>5.595b</td>
</tr>
<tr>
<td>2013</td>
<td>0.0837b</td>
<td>0.01069***</td>
<td>0.0915***</td>
<td>0.0700***</td>
<td>0.0697**</td>
<td>0.0850**</td>
<td>3.701a</td>
</tr>
<tr>
<td>2014</td>
<td>0.0198a</td>
<td>0.528a</td>
<td>0.4468a</td>
<td>0.0812a</td>
<td>0.507a</td>
<td>0.1469***</td>
<td>5.473c</td>
</tr>
<tr>
<td>SED</td>
<td>0.1186b</td>
<td>1.953c</td>
<td>1.5921c</td>
<td>0.3612b</td>
<td>1.301b</td>
<td>3.833a</td>
<td>4.638b</td>
</tr>
<tr>
<td>Tillage (T)</td>
<td>2</td>
<td>0.0378a</td>
<td>1.382b</td>
<td>0.8821b</td>
<td>0.5004b</td>
<td>1.259b</td>
<td>0.1800***</td>
</tr>
<tr>
<td>HINT</td>
<td>0.001309***</td>
<td>0.1127***</td>
<td>0.0857***</td>
<td>0.0854**</td>
<td>0.1041***</td>
<td></td>
<td>4.248a</td>
</tr>
<tr>
<td>LINT</td>
<td>0.001309***</td>
<td>0.1127***</td>
<td>0.0857***</td>
<td>0.0854**</td>
<td>0.1041***</td>
<td></td>
<td>4.381a</td>
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<tr>
<td>N rate (N)</td>
<td>3</td>
<td>0.001309***</td>
<td>0.1127***</td>
<td>0.0857***</td>
<td>0.0854**</td>
<td>0.1041***</td>
<td>4.945b</td>
</tr>
<tr>
<td>NO</td>
<td>4.420a</td>
<td>4.381a</td>
<td>4.945b</td>
<td>5.019b</td>
<td>0.2078***</td>
<td>0.2545***</td>
<td>0.0920***</td>
</tr>
<tr>
<td>N70</td>
<td>4.420a</td>
<td>4.381a</td>
<td>4.945b</td>
<td>5.019b</td>
<td>0.2078***</td>
<td>0.2545***</td>
<td>0.0920***</td>
</tr>
<tr>
<td>N140</td>
<td>4.420a</td>
<td>4.381a</td>
<td>4.945b</td>
<td>5.019b</td>
<td>0.2078***</td>
<td>0.2545***</td>
<td>0.0920***</td>
</tr>
<tr>
<td>N210</td>
<td>4.420a</td>
<td>4.381a</td>
<td>4.945b</td>
<td>5.019b</td>
<td>0.2078***</td>
<td>0.2545***</td>
<td>0.0920***</td>
</tr>
<tr>
<td>SED</td>
<td>0.2939**</td>
<td>0.3599**</td>
<td>0.5090**</td>
<td>0.001309***</td>
<td>0.5090**</td>
<td>0.001309***</td>
<td>0.001309***</td>
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<tr>
<td>YxT</td>
<td>6</td>
<td>0.001309***</td>
<td>0.1127***</td>
<td>0.0857***</td>
<td>0.0854**</td>
<td>0.1041***</td>
<td>4.248a</td>
</tr>
<tr>
<td>YxN</td>
<td>6</td>
<td>0.001309***</td>
<td>0.1127***</td>
<td>0.0857***</td>
<td>0.0854**</td>
<td>0.1041***</td>
<td>4.381a</td>
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<td>T x N</td>
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<td>0.1127***</td>
<td>0.0857***</td>
<td>0.0854**</td>
<td>0.1041***</td>
<td>4.945b</td>
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<td>YxT x N</td>
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<td>0.1127***</td>
<td>0.0857***</td>
<td>0.0854**</td>
<td>0.1041***</td>
<td>5.019b</td>
</tr>
</tbody>
</table>

Values are mean; df, deg
Values followed by same

---

**LSD, Fisher’s Least Significant Difference at P<0.05 for treatments interaction means**
Critical Weed Free Period

Welsh et al. 1999
Critical Weed Free Periods

**Number of weeding operations needed:**

*Trials with onions and swedes*

Weeds had no adverse effects on a crop of bulb onions for up to five weeks after 50 per cent of the onions had emerged. From week five to week seven, however, yields were reduced by 4 per cent for every day that weeds were left uncontrolled. This two-week period was the critical weed-free period for that crop.

Trials with more competitive crops such as swede showed that one single weed removal operation around six weeks after sowing was all that was needed. This gave yields equivalent to that of a crop which was kept weed-free throughout the season.
Conclusions

• Many exciting options on the horizon
• Agronomy decisions can make a big difference on weed competition including
  – Variety
  – Sowing date
  – Grazing
  – Undersowing
• Mechanical weeding is another tool in the toolbox to aid weed control
References

RAU publications


Other publications


• HDRA website http://www.gardenorganic.org.uk/organicweeds/index.php
