# Reducing pesticide inputs in winter cropping systems in the UK

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An arable landscape in England. © Rothamsted Research, UK.

Food Quality and Safety
6TH FRAMEWORK
PROGRAMME

# Reducing pesticide inputs in winter cropping systems in the UK

Good pest management is a cornerstone of the UK's highly productive agriculture and is important to the economy and for food security. Yields compare well amongst countries in Europe but pesticide use is intensive (Table 1), at least in part due to the mild and moist winter conditions.

There are strong pressures to limit the use of pesticides for environmental and health reasons and to preserve their activity from the risk of pesticide resistance. A group of scientists, advisers and farmers in the ENDURE project posed the question, 'What scope is there for farmers to respond to this need while maintaining productivity and profitability?'

**Pollen beetle (*Meligethes aeneus*) on oilseed rape. © Rothamsted Research, UK.**

**Table 1: Yields and number of full doses of pesticides applied to winter wheat in England, France and Denmark**

| | | England 2006 | France 2006 | Denmark 2007 |
|---|---|---|---|---|
| **Yield $t^{-1}$ $ha^{-1}$** | Winter wheat | 8.0 | 7.2 | 7.3 |
| | Winter barley | 6.6 | 6.8 | 5.8 |
| | Spring barley | 5.1 | 5.9 | 4.9 |
| | Winter oilseed rape | 3.4 | 3.0 | 3.5 |
| **Total pesticide doses** | Winter wheat | 6.75 | 4.0 | 2.34 |
| | Winter barley | 4.76 | 3.52 | 2.0 |
| | Spring barley | 2.80 | 2.77 | 1.67 |
| | Winter oilseed rape | 5.78 | 6.0 | 2.7 |

Data from: Denmark: Miljøstyrelsen: Bekæmpelsesmiddelstatistikken. UK: TFI calculated from data from the Food and Environment Research Agency (Fera), Sand Hutton, Yorkshire. Yield data from Defra Statistics (Department for Environment, Food and Rural Affairs). France: Ecophyto R&D report Guichard *et al.*, 2009

## Why do we need a fresh look at the whole cropping system?

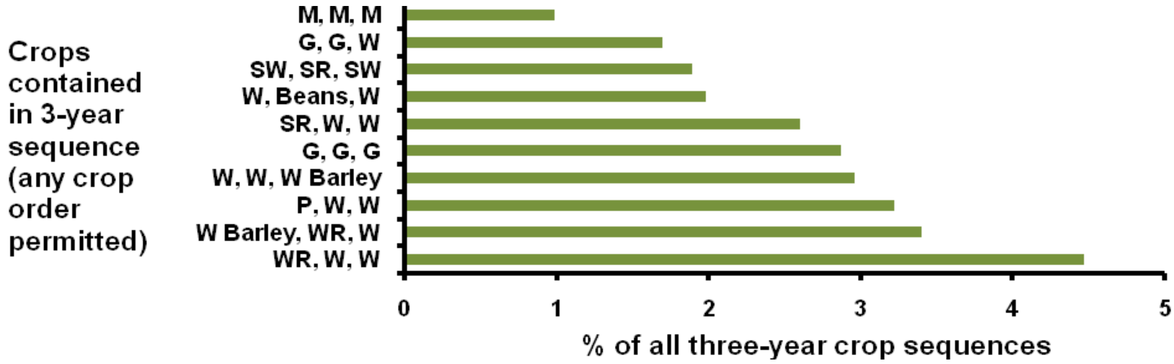
The severity of pest problems is influenced not only by the technologies used for pest management but by the cropping system as a whole, including the sequence or 'rotation' of crops, the season of cropping (winter or spring-sown) and crop management. Many agronomic operations interact with each other and can influence pests. Crop rotation interrupts cycles of pest build-up and is a fundamental tool for maintaining both crop health and soil fertility. Together with crop protection technologies, it must be a key consideration in any study of pesticide use. Here we review pesticide use in winter cereal based cropping systems in the main arable area of England. We assess the potential for reducing the use of pesticides and highlight some of the means by which this could be achieved.

**Tractor ploughing heavy clay soil. © Rothamsted Research, UK.**

## What do crop rotations in the UK look like today?

UK Arable rotations are dominated by cereals, with oilseed rape or, less often, pulses as break crops. There was remarkable variability amongst 1100 three-year crop sequences recorded from 1992-2004 in 256 fields used in the Farm-Scale Evaluations of GM crops. Even the most common three-crop sequence occurred in less than one in twenty fields (Fig. 1).

**Figure 1: Most common three-year crop sequences in a survey of 256 fields in the UK 1992-2004.**




**Key to crops: M = maize; G = grass; P = peas; W Beans = winter beans; W Barley = winter barley; SR= spring oilseed rape; WR = winter oilseed rape; SW = spring wheat; W = winter wheat.**

(Data from: Bohan, DA, Powers, SJ, Champion, G, Haughton, AJ, Hawes, C, Squire, G, Cussans J and Mertens, SK. 'Modelling rotations: can crop sequences explain arable weed seedbank abundance?' *Weed Research*, in press)

## Current pesticide use reflects the importance of different pests

Herbicides and fungicides account for the largest share of pesticide usage in cereals and oilseed rape in England but the use of insecticides is also significant in winter crops (see Table 2 on the following page). The most significant problems include black grass, bromes, *Septoria*, yellow rust, *Phoma*, light leaf spot, *Sclerotinia*, aphids/virus, flea beetle, pollen beetle and slugs. There are problems with pesticide resistance, for example in black grass, *Septoria* and pollen beetles. For many farmers, weeds are their first priority in pest management. Mild wet winters associated with a maritime climate provide a long growing season for weeds. Herbicide resistant black grass requires a particularly high herbicide input, full rates of herbicides and tank mixtures of multiple products are routinely applied to achieve control. Continuous autumn-sown cropping is prevalent in much of the UK. Without a winter break from cropping, grass weed management is difficult, increasing the need for herbicide.

**Septoria (*Mycosphaerella graminicola*) leaf blotch on wheat. © Rothamsted Research, UK.**

Mild and moist winters also encourage fungal diseases. For example, the severity of *Septoria (Mycosphaerella graminicola)* blotch in cereals is often high because there is continuous infection from ascospores throughout the autumn and winter. Fungicide use is also encouraged by the responsiveness of higher yielding cultivars to fungicides and by significant problems of fungicide resistance. Pressure from customers (millers and merchants) with regard to mycotoxins encourages farmers to apply higher doses or additional applications of fungicide sprays (for example, ear sprays) and use growth regulators.

As for weeds and diseases, problems with invertebrate pests are also exacerbated by the mild winter climate, facilitating the spread of virus by aphids, and increasing slug activity. Significant areas of wheat are threatened by wheat blossom midge and oilseed rape is at risk from insecticide resistance in pollen beetles; both of these can increase insecticide usage.

**Table 2: Total full doses of different pesticide classes applied to cereals and oilseed rape in England in 2006 (calculated from data supplied by Fera)**

| | Winter wheat | Winter barley | Spring barley | Oilseed rape |
|---|---|---|---|---|
| **Herbicides** | 2.43 | 1.97 | 1.51 | 2.27 |
| **Fungicides** | 2.26 | 1.32 | 1.01 | 2.12 |
| **Insecticides** | 0.96 | 0.82 | 0.14 | 1.10 |
| **Molluscicides** | 0.12 | 0.02 | 0.01 | 0.30 |
| **Growth regulators** | 0.97 | 0.63 | 0.14 | - |
| **Total** | 6.74 | 4.76 | 2.81 | 5.78 |

## Structural and economic factors influence pesticide usage

The growing size of UK farms and the use of contractors tends to lead to increased early drilling. September drilled wheat crops are associated with high disease risk and can lead to problems with grass weeds such as black-grass and brome - particularly if reduced tillage is used. This leads to more use of fungicides and herbicides (as well as growth regulators).

Smaller workforces make monitoring of individual fields more difficult and reduce the flexibility to precisely time pesticide applications. Moreover, during the growing season the economic optimum for pesticide application on individual fields is difficult to estimate in the context of the increasingly volatile market in which farmers operate. This probably leads to risk-averse decision-making and more pesticide use.

**Fusarium head blight on wheat.**
**© Rothamsted Research, UK.**

## What pesticide reductions could be achieved?

A group of scientists, advisers and farmers came together under the ENDURE project to consider what agronomic and technological tools for reducing pesticide use are available to farmers or will become available within the next 10 years. They then assessed what potential these tools offered for reducing pesticide use in winter crop based systems in the main arable area of England, using expert knowledge and measured data where available. The group set themselves the goal of proposing systems that would use less pesticide while maintaining farm income and crop yields.

## Up to 25% pesticide reduction through changed crop rotations

Changing crop sequences and/or lengthening the rotation could make an important contribution to reducing pesticide use. Diversification of the rotation to include spring crops and a greater variety of crop species can particularly reduce problems with weeds and fungal diseases. Spring cropping provides an opportunity to better manage weeds by tillage and non-selective herbicides and is valuable for containment of grass weeds such as black grass. This strategy is less practical on heavier soils where it is more difficult to create a spring seed bed. Introduction of a fallow year could even be a realistic option in case of serious problems with herbicide resistant black grass. Lengthening the rotation to increase the time to recurrence of the same crop is likely to reduce disease pressure.

The ENDURE group proposed seven rotations, all four years or longer, all using commonly grown crops and with progressively smaller proportions of winter cropping. Fallows were proposed as an option for fields with severe grass weed problems. The average annual number of full doses of pesticides associated with the current rotation (6.4 doses) and with the proposed rotations were calculated and compared with the most common three-year crop sequence (winter wheat - winter wheat - winter oilseed rape; Table 3).

**Spring barley being grown instead of winter wheat to provide greater options for grass weed control. © Rothamsted Research, UK.**

Changes in crop rotation alone, with no other changes in management, could reduce annual pesticide use by 6-25% (Table 3). It should be emphasised that the group proposed these rotations as an exercise in exploring options. Although there are more 'first wheats' in rotations 1-4 (Table 3), wheat production is likely to be significantly reduced in all seven rotations. It is also doubtful that there would be an attractive market for a large increase in bean production. Although achieving significant reduction in pesticide use, wide adoption of the proposed rotations would have potential impact on profitability and productivity both at the farm and the national level.

**Table 3: Estimated reductions in average annual pesticide use achieved by changing crop sequences and using off-the-shelf or developing technologies**

| **Crop rotation** | | | | | | **% change in average annual pesticide doses** | | |
|---|---|---|---|---|---|---|---|---|
| **Rotation number** | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Effect of crop sequence change only | Effect of crop sequence change plus changed practices | |
| | | | | | | | Off-the-shelf technologies | Developing technologies |
| **Current** | W | W | WR | | | | | |
| **1** | W | S Beans | W | WR | | - 6 | -27 | |
| **2** | W | S Beans | W | S Wheat | WR | -18 | -36 | -49 |
| **3** | W | S Beans | W | S Barley | WR | -16 | -35 | -48 |
| **4** | W | S Beans | W | Fallow | WR | -19 | | -48 |
| **5** | W | S Beans | S Wheat | WR | | -24 | | -56 |
| **6** | W | S Beans | S Barley | WR | | -22 | | -54 |
| **7** | W | S Beans | Fallow | WR | | -25 | | -55 |

**Key to crops: W = winter wheat; WR = winter oilseed rape; S Beans = spring beans; S Barley = spring barley.**

## 20% pesticide reduction with off-the-shelf technologies

The ENDURE group next posed the question 'what additional pesticide use reduction could be achieved if currently available technologies were fully implemented in these rotations?' Addressing the three least radical of their suggested rotations, they estimated that a further 20% reduction in pesticide use could be achieved using off-the shelf technologies (Table 3, rotations 1-3) producing up to 36% reduction when combined with that achieved by the rotation change.

### Some off-the-shelf technologies:

**Pesticide targeting and resistance management:**

> Ensure effective and timely use of pesticides strictly according to need; using economic thresholds, forecasting and decision support systems.

**Weed management:**

> Consider ploughing for grass weed management before a second cereal.
> Before spring crops plough if necessary in spring (in autumn on heavy land) to create seedbed and for weed control.
> Use higher seed rates and cultivars with strong competitiveness.
> Spot mapping and targeting of weeds.

**Disease management:**

> Resistant cultivars.

**Invertebrate pest management:**

> Conservation biological control: provide refuges and resources for natural enemies.
> Minimise tillage and chop straw wherever possible to conserve natural enemies.
> Plough or roll if necessary for slug control.
> Resistant cultivars.

## 30% pesticide reduction with new and near-to-market technologies

Finally, the group asked what additional pesticide use reduction could be offered in the next 10 years by the continued development of existing technologies and the maturation of new or near-to-market technologies. They tested this on all but the least radical of the rotations. It was estimated that a remarkable 48-56% reduction in pesticide use might be achieved in comparison with current practice in a wheat-wheat-rape rotation, a 30% reduction being contributed by the technologies (Table 3).

### Some new and near-to-market technologies:

**Pesticide targeting and resistance management:**

> GPS-controlled pesticide applications for accurate pesticide targeting and stewardship and to reduce soil compaction and crop damage.
> Improved forecasting and decision support.

**Weed management:**

> Drilling OSR into wide-rows to enable targeted herbicide or mechanical weeding and targeted nutrient application to avoid fertilising.

**Disease management:**

> New resistant cultivars.
> In-row targeting of fungicides in oilseed rape.

**Invertebrate pest management:**

> New resistant cultivars.
> In-row targeting of insecticides in oilseed rape.
> Trap cropping in oilseed rape.

## Would such changes to cropping systems be sustainable?

The proposed cropping systems would be more environmentally sustainable than a wheat-wheat-rape rotation with current practice. However, the crop rotations that could achieve the maximum pesticide reduction (around 50%) in the next decade are likely to be less profitable because of the inclusion of less productive and less profitable spring crops (or fallow) for weed management. Such crop rotations could only be recommended where there are significant problems with herbicide-resistant grass weeds.

By contrast, new and developing technologies could enable pesticide use reductions of 20% currently and 30% in the next decade without such risks to profit or productivity. Environmental benefits associated with these technologies are likely to be less dependent on the crops in the rotation, enhancing biodiversity and natural enemies but also reducing fuel use and emissions.

## Implications for policy makers

Beyond the farm scale, the proposed rotations have clear strategic implications for policy makers. The crop rotations that achieved the largest reductions in pesticide use had smaller proportions of wheat, a major staple and traded commodity. Broad adoption of these rotations is unlikely to be economically sustainable. The rotations that are currently most common are likely to better address issues of food security and profitability but could still be accompanied by 20-30% reductions in pesticide use in the next decade if research and development continues and best practice is adopted.

**Above: Black grass in wheat.**

**Below: Wheat is a major staple and traded commodity.**



## In conclusion

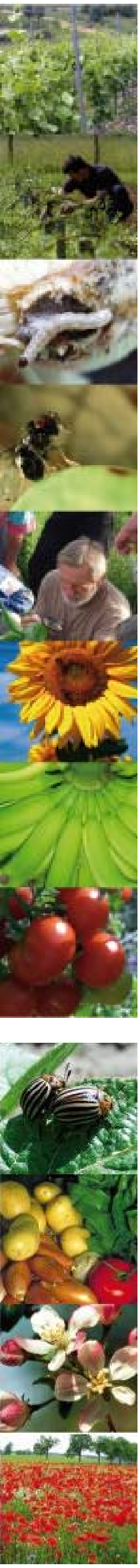
New management technologies and changes to cropping offer remarkable potential to achieve reductions in pesticide use in winter cereal based cropping systems but there is a trade-off between changing crops to minimise pesticide use and the need to maintain productivity.

## Where next?

The ENDURE group's conclusions have strategic implications for farmers, advisers, scientists and policy makers alike. If the complex balance between pest management, the environment, profitability and food production is to be struck, there must be:

> A free flow of information and ideas between stakeholders.
> Appropriate research and development.
> Readiness to adopt new practices.
> And a policy framework that encourages all three.

**From Science to Field**
**Winter Crops Based Cropping Systems (WCCS) Case Study - Guide Number 3**



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## Summary

Pest management is a cornerstone of the UK's highly productive agriculture but pesticide use is intensive. ENDURE has assessed the potential for reducing pesticide use in winter cereal based cropping systems in England in the context of the need to maintain productiveness and income. Rotations in the wheat growing areas of England are highly variable but are dominated by winter-sown cereals and oilseed rape with some pulses. Herbicides and fungicides account for the largest share of pesticide usage, in part due to mild and moist winter conditions. For many farmers, weeds are their first priority in pest management. The ENDURE group explored the contribution that new pest management technologies and changes to cropping could make to pesticide reduction. They considered rotations using commonly grown crops, but with smaller proportions of winter cropping, and new technologies available now or likely to be available in the next 10 years. It was estimated that changed cropping alone could reduce annual pesticide use by 6-25% but would entail a trade-off with productivity and profitability. By contrast, new and developing technologies could enable pesticide use reductions of 20% currently and 30% in the next decade without such risks to profit or productivity.


## For further information please contact:


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## About ENDURE

ENDURE is the European Network for the Durable Exploitation of Crop Protection Strategies. ENDURE is a Network of Excellence (NoE) with two key objectives: restructuring European research and development on the use of plant protection products, and establishing ENDURE as a world leader in the development and implementation of sustainable pest control strategies through:

> Building a lasting crop protection research community
> Providing end-users with a broader range of short-term solutions
> Developing a holistic approach to sustainable pest management
> Taking stock of and informing plant protection policy changes.

Eighteen organisations in 10 European countries are committed to ENDURE for four years (2007-2010), with financial support from the European Commission's Sixth Framework Programme, priority 5: Food Quality and Security.

## Website and ENDURE Information Centre:

**www.endure-network.eu**


This publication was funded by EU grant (Project number: 031499), under the Sixth Framework Programme, and is catalogued as Winter Crops Based Cropping Systems (WCCS) Case Study – Guide Number 3, published in November, 2010.