Crop rotation and legumes cultivation: Effective measures to increase the environmental performance and long-term viability of European agriculture.

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Global food security

A threefold challenge now faces the world:

• Match the rapidly changing demand for food
• Do so in ways that are sustainable
• Ensure that the world’s poorest people are no longer hungry

This challenge requires changes in the way food is produced, stored, processed, distributed, and accessed that are as radical as those that occurred during the 18th- and 19th and .... 20th-centuries

Godfray et al. 2010
Going beyond diversification

- Proposals for “greening” must change farming practice to have an effect
- Most arable farmers already grow 3 crops – requiring this would only impact 2% EU arable areas (EC, 2011)
- In annual cropping, we need to be clear about the difference between spatial and temporal diversification
- Requiring 3 crop “groups” would have a major impact
Rotations are unfashionable

- A rotation is a temporal arrangement of crops on the same piece of land
- Advantages of rotations ("the rotation effect") have been recognised for 1000s of years
- However, conventional agriculture has moved towards monoculture or shortened/simplified rotations - wide and cheap availability of fertilisers and agrochemicals has been key
- Extended rotations and ley-based rotations are less common in conventional but still fundamental in organic farming
- Market forces, subsidy etc have an important impact on crop choice as well as technology, biophysical constraints etc
- Rotations interact with other aspects of the farming system e.g. tillage and fertilizer, along with soil and climate
## Principles of rotation design

<table>
<thead>
<tr>
<th></th>
<th>Profit</th>
<th>Soil C &amp; soil structure</th>
<th>N supply</th>
<th>Weed control</th>
<th>P&amp;D control</th>
<th>Bio diversity</th>
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</thead>
<tbody>
<tr>
<td>Economically balanced</td>
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<tr>
<td>Alternate N fixing/demanding crops</td>
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<tr>
<td>(USING LEGUMES)</td>
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<td>Alternate autumn/winter sown</td>
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<td>Alternate root biomass/depth</td>
<td></td>
<td>***</td>
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<tr>
<td>Alternative weed management</td>
<td>**</td>
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<tr>
<td>Differing pest/disease susceptibility</td>
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<tr>
<td>Catch crops &amp; green manures</td>
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<tr>
<td>Fit to labour/machinery etc availability</td>
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Rotations still allow flexibility (from Castellazi et al. 2008)
Economic consequences

➢ Market prices change constantly so data on past profit not always a reliable guide to the future!

➢ Impact of rotations on yield and quality

➢ Rotations can reduce system costs and a benefit in terms of risk

➢ Need to cost the rotation not the individual crops

➢ In organic stockless systems, fertility building crops may have no direct economic output.
How does rotation design influence yield?
A UK oilseed rape (OSR) example

<table>
<thead>
<tr>
<th>Rotation Design</th>
<th>Yield t/ha (85% dry matter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous OSR</td>
<td>2.79</td>
</tr>
<tr>
<td>OSR one year in two</td>
<td>3.13</td>
</tr>
<tr>
<td>OSR one year in three</td>
<td>3.36</td>
</tr>
<tr>
<td>First OSR</td>
<td>3.9</td>
</tr>
</tbody>
</table>

- Wheat/OSR rotations
  - Foliar/stem diseases do not explain this
  - Exploring below-ground pathogens not normally associated with OSR
- Ongoing research
- Stobart (2011)
Rotations for weed management

“Rotation of crops…is the most effective means yet devised for keeping land free of weeds. No other method of weed control, mechanical, chemical, or biological, is so economical or so easily practiced as a well-arranged sequence of tillage and cropping.”

— C.E. Leighty. 1938 Yearbook of Agriculture

• Weeds live in ecological niches
• Crop ability to compete
• Timing of field operations
• Value of forage crops (leys)
• Response to different nutrient levels
• Row crops as cleaning crops
• Cover crops
• But weeds have biodiversity value
Effect of length of forage crop on weed seedling emergence (Anderson 2010)

Figure 4. Seedling emergence of the weed community in alfalfa across time. Data are expressed as a percentage of highest emergence in the first year, and averaged across several studies. (Adapted from Harvey and McNevin\textsuperscript{11}, Entz et al.\textsuperscript{12} and Ominski et al.\textsuperscript{13}.)
The Nitrogen Question
Fertiliser manufacture and imported feed has changed Europe’s nitrogen cycle

From the European Nitrogen Assessment
World N fertilizer use (FAOStat)

Million tonnes of N fertilizer

- World
- Developing
- Developed (Europe, N America, Oceania)

Year:
- 1961
- 1971
- 1981
- 1991
- 2001

SEVENTH FRAMEWORK PROGRAMME
European livestock production depends on imported protein – quantity or land outside Europe

FAO data

Von Witzke & Noleppe 2010
Changes in areas planted with selected legume crops (EU 27)

- Beans, dry Area Harvested (Ha)
- Peas, green Area Harvested (Ha)
- Soybeans Area Harvested (Ha)
- Peas, dry

FAOSTAT
Legumes in rotations - examples

Benefits - diversification (of crop families)
- reduced fertiliser use (direct/indirect)
- crop yield
Legumes in European agricultural systems

Photos: Christine Watson
Three crop sequences and their impact on production in Sweden

Sequence A
- Oilseeds
- Winter wheat
- Oats
- Undersown barley
- Grass/Clover ley 1
- Grass/Clover ley 2

Sequence B
- Oilseeds
- Winter wheat
- Oats
- Undersown barley
- Grass ley 1
- Grass ley 2

Sequence C
- Oilseeds
- Winter wheat
- Oats
- Barley
- Spring wheat
- Fallow
Winter wheat yields at Lanna - effect of 2-year leys

Persson, Bergkvist & Kätterer (2008)
So where do rotations and legumes fit into the CAP 2013 proposals?
Policy integration

"We need nothing less than a CAP that respects soil and water and promotes practices that use them in a sustainable and resource-efficient way. We also need a CAP that can invest in protecting and restoring them (soil and water) when they have been degraded, contaminated or polluted,"

a "profound greening" of the CAP.

Commissioner Janez Potocnik
(photo: Inspirit)
• Diversifying cropping – longer rotations with different crop families
• Benefits of sequence not simply more species
• Changes can be simple or radical
• Intercrops have a part to play
• Legumes one valuable option
• In grassland, legumes can easily be incorporated at little cost

Image: Wordle
The CAP towards 2020 – some issues

• Long-term benefits vs short-term gain
• Need for knowledge exchange
• Value of early adopters (transfer of knowledge from organic production an advantage)
• Value to consumers – environmental certification schemes
• Carrots, sticks and sermons!
THANK YOU!
References


