Cropping Systems for Sustainability and Food Security

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Cathy Hawes, from the James Hutton Institute’s (JHI) Centre for Sustainable Cropping (CSC), gives an overview of the work being carried out at the Centre looking at sustainable cropping and the long term trends in yield, biodiversisty and soil health. JHI is a LEAF Innovation Centre.

Background

The drive to increase arable productivity and the associated increase in the use of non-renewable resources have resulted in increases in yield, but in some cases at an environmental cost. There is an increasing focus on ‘sustainable intensification’ - which includes approaches aimed at increasing the efficiency of crop production without requiring an increase in land area or that lead to environmental damage. Examples include precision farming, pest and disease forecasting, reduced tillage, recycling and reducing waste, intercropping and many others. However, little is known about the long term efficacy of these different measures, or the likelihood that they will achieve the conflicting goals of simultaneously increasing environmental sustainability and crop yield in the long-term.

Not only must food be produced in a sustainable way, but the increased production that is necessary to match the growing human population must also overcome the ceiling in crop yield that appears to have been reached in some areas of highly productive agriculture, such as the UK (Defra, 2011). One possible reason for this yield plateau is that, despite the high levels of nutrients being applied, there are limitations to the rate at which plants are able to uptake and utilise them. Soil physical conditions can limit the rate at which roots grow and so limit the overall volume of soil that the roots can explore, restricting the rate at which plants access water and nutrients, which can limit yields (Whiteley and Dexter, 1982).

The Centre for Sustainable Cropping

Whole-systems research at an appropriate spatial and temporal scale is required to answer these questions. The James Hutton Institute’s Centre for Sustainable Cropping (CSC) was established in 2009 as a long-term platform for whole system, cross-disciplinary research on arable sustainability. The general aim of the Centre is to design a sustainable cropping system that:

• Maintains yield quality and yield stability at lower levels of non-renewable agrochemical inputs
• Reduces losses from the system, including greenhouse gas (GHG) emissions, nutrient leaching and soil erosion
• Enhances soil quality and arable biodiversity

The sustainable cropping system currently includes:

• Non-inversion minimum tillage (10cm)
• Tied-ridging in potatoes to reduce tramline erosion
• Compost addition pre-sowing (@ 35 t/ha)
• Reduced artificial N fertiliser (70% with further reductions planned as soil fertility improves)
• Reduced dose herbicide (50% of the conventional, or alternative chemical to promote a Diverse but low abundance dicot weed flora - aiming at 10% cover)
• Threshold crop protection applications, and reductions where possible based on HGCA dose response curves
• Clover undersowing of spring barley crops for additional N input to the rotation
• Green cover (oil radish) over winter before spring crops to trap soil N and reduce leaching

The effect of this sustainable management on long-term trends in yield, biodiversity and system (soil) health is being assessed by comparison with standard conventional agronomic practice over a six course rotation of potato, wheat, spring beans, spring barley, winter oilseed and winter barley. Crop varietal differences have been found in their sensitivity to cropping system and soil physical conditions (e.g. Masle, 1992). Variation in the yield, crop health and quality of 5 different cultivars of each crop are being tested on the platform. Full results will be reported at the end of the first six year crop rotation in 2016. However, the effects of different tillage systems on spring barley cultivars have already been demonstrated as part of an associated long term disturbance experiment at the JHI (Newton et al 2012).

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A whole-systems approach for optimising crop production, biodiversity and system health for long term food security.

A long-term tillage experiment at the JHI

Five tillage treatments were established in 2003 that imposed different amounts of soil disturbance: (T1) zero tillage, (T2) minimum tillage to 7 cm depth and ploughed treatments followed by power harrowing consisting of (T3) conventional plough to 20 cm depth, (T4) plough to 20 cm followed by compaction by wheeling the entire plot with a tractor fitted with 8.8 Mg total load and (T5) deep plough to 40 cm depth. The different forms of tillage applied influenced the soil physical conditions: penetration resistance measured in April was markedly different between plots, with deep plough having the least impedance to root growth, whereas zero and minimum tillage had greatest impedance in the topsoil.
Four winter barley cultivars (Sumo, Fanfare, Pastoral and Pipkin) were selected based on contrasting rooting characteristics, disease resistance and yield sensitivity. They were planted in plots as monocultures and as all 2-, 3- and 4-component mixtures. Overall, crop responses to tillage treatment reflected the effect of treatment on soil physical conditions. On average, conventional and deep plough conditions generally gave higher yields, but there were significant differences in the responses of the four cultivars to different tillage systems. Sumo gave the highest yield under deep plough conditions, whereas Pipkin was the best cultivar under conventional and zero tillage conditions. These observations imply that the traditional breeding approach that relies on highly favourable growing conditions may not identify lines that perform better under reduced tillage. Looking at a much wider range of barley genotypes might reveal stronger interactions with soil tillage. If such genotypes can be identified, then they may still best be deployed in mixtures as soil conditions are highly variable between seasons, and mixtures ensure that responsive cultivars are always present and ready to utilise available resources.

Cultivar responses to reduced tillage compared to conventional plough will continue to be monitored here and at the CSC. These early indications suggest that there could be scope for further improvements to minimum tillage yields via more specific cultivar selections – watch this space!

More information about the work being carried out at the Centre for Sustainable Cropping, can be found at: www.hutton.ac.uk/csc

References


