Focus Site Project Review

Trialling soil nutrient mapping and precision farming techniques

Dudwell, Camrose, Haverfordwest, Pembrokeshire, SA62 6HJ

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1 Summary

Dudwell Farm, Camrose is currently a Farming Connect Focus Site. The 283 hectare (700 acre) owner occupied holding is farmed by father and son, Charles and Tom Rees. With both arable and livestock, the farm grows 182 hectares (450 acres) of cereals including winter wheat, spring barley, winter and spring oats and winter sown oilseed rape. In addition to this, the farm is home to 250 breeding ewes, 15 beef suckler cows and calves as well as 50 beef store cattle. Forty hectares (100 acres) of woodland is currently managed under the Glastir Advanced agri-environment scheme.

Business aspirations:

To develop a bespoke fertiliser application system across the farm, to increase productivity and optimise costs.

To develop and implement a nutrient input approach that tailors recommendations to not just specific field/crop requirements, but also provides detail for the range of requirements within each field.

To adjust fertiliser application rates –taking a within field approach- to target inputs on areas with poor nutrient status to improve productivity and yield.

To reduce fertiliser inputs on areas that do not require additional nutrients, to both save on costs and environmental damage caused by nutrient run off.

To apply digital soil sampling across all fields.

Tom relies heavily on regular soil sampling across all his arable and livestock fields to determine the most cost efficient way of meeting crop requirements.

This regular soil evaluation has helped in cutting the substantial costs associated with fertiliser inputs, even though the fertiliser has been applied as a single rate dressing. However, with the advice and guidance of precision farming expert Ian Beecher-Jones, Tom hoped to further evaluate different soil mapping options to help him arrive at a method that provides the most fitting representative sampling cover for the least cost.

Focus Farm Project key objectives:

To trial precision farming technology at Dudwell Farm, and then share their experience with the wider industry, on the value of assessing nutrient variations in their soils and tailoring nutrient inputs accordingly. The project aimed to:

1. Identify and evaluate different soil sampling techniques across two fields- one in arable production and one in grassland production.
2. Analyse subsequent soil sampling results and compare the zone sampling techniques for variation.
3. Provide knowledge transfer to other farmers on determining the most cost effective method of providing an accurate measure of soil differences in a field.
4. Demonstrate best practice in nutrient management to farmers in the Cleddau river catchment, which is currently under consideration for NVZ designation.

A new generation of technologies, such as precision farming has allowed many forward thinking farmers to gain a better understanding of their farmland, and provide accurate information when looking to improve and maintain arable and grassland.

Soil nutrient mapping allows virtual boundaries to be created within a field whilst also soil sampling.

To determine the soil zones electronically and then sample those zones, soil electrical conductivity (EC) is used to grid sample the field through splitting the field area into 1ha grids with the intention of then taking samples from the centre of each grid zone.

Soil testing of nitrogen, phosphate, potash, pH and soil type classification will then show the differences in the soil nutrient status across all sampling grids. This allows for informed management decisions to be made, which should in turn save money, optimise production and improve land condition.

What is Electrical Conductivity (EC)?

Electrical Conductivity (EC) is a method of precision farming that measures how easily an electrical current flows through a material such as soil. The electrical conductivity of a soil sample will indicate the amount of salt, sand, clay, organic matter and water it contains. With GPS input such indications can be used to create soil maps. Measurements can be taken at two depths, referred to as a shallow array and a deep array measurement, with the relationship between the two providing valuable and useful information to farmers[1].

The cost of this type of precision sampling ranges from £15-£25/hectare, and needs to be repeated every 3-5 years.

Trialling two different soil sampling companies throughout the project ensured that soil nutrient knowledge gathered was accurate across the growing areas, and provided Tom with more information to tailor his future management options.

1.1 Project Conclusions

Soil Nutrient Mapping resulted in informed management decisions

Precise mapping across fields demonstrated the wide range of variation in indices across individual fields.

In one field, sampling showed a huge range in the phosphorous level, from a low of 1 in some parts to a high of +3 in others. Potash ranged from 0 to 3+, and pH varied from 5.3 in some parts to 6.3 in others. Traditional soil sampling assessment techniques, whilst valuable, would not have provided this level of detail.

Soil nutrient mapping has allowed Dudwell Farm to adjust its fertiliser application rates within a single field. The mapping tool has resulted in a more targeted treatment regime with higher inputs applied to those areas with poor nutrient status and reducing inputs on those that don't need additional nutrients. This creates a more informed management process, allowing farmers to be fully aware of their own farm conditions and confident in their approach to its management strategies.

The results at Dudwell indicated more variation across each of the selected fields, however, the variation was different to that which Tom was expecting. It is likely that such technology has allowed Tom to gain

[1] AHDB. 2009. Precision Farming Glossary. AHDB. Available from: https://cereals.ahdb.org.uk/media/185207/pf_gls1-precision_farming_glossary_2009.pdf. (Accessed 15th June 2018).

a deeper and more up to date understanding of conditions within each field sampled. This will help not only ensure that inputs are utilised effectively but it will also limit environmental impact caused by such inputs.

Soil Nutrient Mapping doesn't necessarily reduce financial costs associated with fertiliser application but does reduce inefficiencies associated standard applications.

When considering whole farm fertiliser costs, there were no savings to be made at this early stage, but the soil nutrient planning process did result in more accurate redistribution and application across the farm. As a result of this redistribution, savings are expected to be made in terms of efficiency and productivity in the longer term.

In the short term however, there may be an increase in cost, if getting all grid squares up to optimum soil indices is a priority for the farm. Having gained a clear understanding of each 1ha grid square and their soil indices, tailored fertiliser applications will help ensure optimum conditions across all parts of the field, to assist in increasing production levels.

For those areas where an increase in application rates is required, once target indices have been achieved, savings will be made longer term, as those grid squares will only require maintenance applications, rather than a standard (excessive) application.

Ensuring fertiliser is managed in accordance to requirements will also limit the environmental impact caused by such inputs. Applying adequate rates of desired fertiliser will allow the plant to take up nutrients, keeping runoff to a minimum and limiting damage to watercourses and other resources.

The impact on crop growth from applying variable rates of P, K and lime proved difficult to categorically prove.

Variable applications of P, K and lime, and their impact on crop growth proved incredibly difficult to assess in the project, partly due to its short timescale, and a range of other factors. Additional soil factors such as nutrient lock up, the limitations of micro nutrients and the nutrient limiting factors of crop growth are all reasons that may influence this, and assessing these was not within the scope of the focus farm project.

Determining which company provides the most accurate analysis process was challenging, but consistency is key.

Two companies were used to provide clarity throughout the project using different methods. Results from the both companies weren't vastly different, which is a good outcome as regards assessing accuracy of information. However, there was no indication as to which method was the most appropriate as regards longer term usage. One conclusion is that it would be important to stay with the same provider to ensure consistency when comparing results over time.

1.2 Farmer's perspective of the project.

Tom said the digital maps produced, used in combination with new yield monitoring equipment the business had invested in this year, would allow fields to be managed more efficiently.

"What the soil mapping has basically done is put the old boundaries back in the fields but has also gone a step further, splitting parcels of land into even smaller areas according to nutrient status,'' he said.

"Rather than working with a field of six or seven hectares we will now be managing that field in areas of one or one-and-a-half hectares.''

Tom and Charles plan to use digital soil sampling in all their fields in due course, and reflect that the technology has particular relevance for use in fields next to watercourses.

"Agri pollution is a problem that all farmers must deal with, this technology can allow us to manage nutrients more effectively. Any nutrients that are running off because a field doesn't need them is money wasted so applying these in accordance with soil indices will not only be better for the environment but for farm costs too.''

1.3 Other take home points for the industry:

Effective soil analysis and nutrient management will result in informed management decisions.

Being aware of soil nutrient status across the whole farm is part of a wider management strategy that involves; targeted applications of fertiliser, reduced environmental pollution and increased farm efficiency and productivity.

Take action NOW and ask yourself:

- Do you have an evidence based understanding of the nutrient status of all fields on the farm?
- Do you have a nutrient management plan?
- Do you routinely soil sample, testing for nitrogen, phosphate, potash and pH?
- Do you have an understanding of varying soil types across the farm?
- Do you apply fertiliser in accordance with soil indices?
- Is fertiliser applied at optimum timing for efficient plant uptake?

Take action for improved efficiency and productivity through:

- Using a nutrient recommendation system, such as Nutrient Management Guide (RB209)
- Develop a nutrient management plan such as Tried and Tested or PLANET
- Sample soils for pH, phosphate, potash and magnesium every three to five years
- To get better accuracy, look to sample for within field variations, and tailor applications to this information
- Check throughout the season for any visible problems
- For diagnosis, take soil or herbage/crop samples from good and poor areas of the field[2]

Be pro-active in gaining professional advice

Gaining professional advice from specialist agricultural consultants, who are FACTS accredited will be of value when nutrient planning. Using specialists for nutrient management planning will ensure practices are appropriate for individual farm circumstances and ensure efficiency through management practices for increased performance and productivity. When using agronomists for data collection, best practice would be to continually use one data collection technique supplied by your chosen company to ensure consistency, as there may be some variation in results depending on techniques used.

[2] AHDB. 2016. *Managing Nutrients for Better Returns.* AHDB. Available from: https://beefandlamb.ahdb.org.uk/wp-content/uploads/2016/11/BRP-Managing-nutrients-071116.pdf. (Accessed 18th June 2018).

2 Project Review

2.1 Aim of the project

1. To identify and evaluate different soil sampling techniques across two fields one in arable production and the other a grassland field
2. To analyse subsequent soil sampling test results and compare the zone sampling techniques for variation
3. To provide knowledge transfer to other farmers on determining the most cost effective method of providing an accurate measure of soil differences in a field
4. To demonstrate best practice in nutrient management to farmers in the Cleddau river catchment which is currently under consideration for NVZ designation.

2.2 Methodology

The fields were sampled as follows:

- A field average measurement
- Tom Rees creating soil zones manually with average zone samples taken
- The sampling company carry out a Soil Conductivity test to identify the soil zones electronically and then sample the electronic zones
- Carry out a grid sample of the field in 1ha grid squares and samples taken from the centre of each grid square
- Two sampling companies were invited to carry out the testing process
- The tests were carried out in similar conditions and results sent back to be analysed. The testing was delayed due to the heavy rain during the winter and spring
- The results were compared and conclusions drawn out on the differences between the different sampling techniques

2.3 Results

2.3.1 Variations within fields confirmed.

For instance, in one field, sampling showed a huge range in the phosphorus level, from a low of -1 in some parts to a high of +3 in others while potash ranged from 0 to 3+. pH varied too – from 5.3 in some parts to 6.3 in others.

In one of the example fields, the field average was 2-.

1+	2	2-	2	2	2-	1+	3-

However, when assessing the zones sampled within that field (i.e. the 8 zones as outlined above):

- 2 zones are below the average – 25%
- 2 zones are average – 25%
- 4 zones are above the average – 50%

Therefore, it can be concluded from this that only 25% of the field fits with the overall field average of 2- underpinning the benefits of taking a more specific within field approach. The danger is that a blanket application rate of fertiliser, using a field average approach will lead to fertiliser being wasted in some parts of the field and not enough applied in other parts.

A decision between the farmer and the agronomist will be made using a number of factors including soil type, cropping and desired index level in that field regarding the amount of fertiliser to be applied.

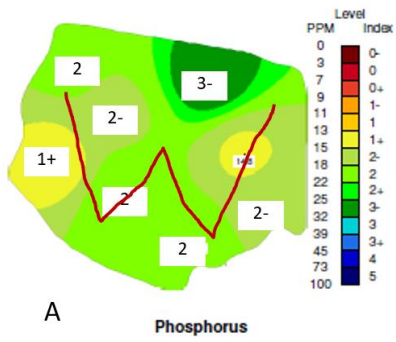
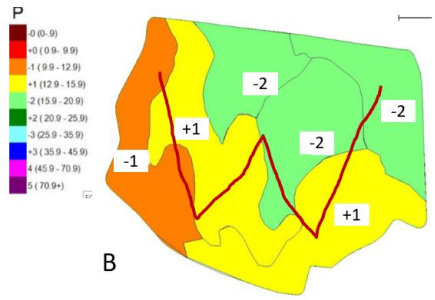
2.3.2 Different Soil Nutrient Mapping companies produced similar results

Both companies tested the farmer selected grid zones and company results were very similar. With the tests being sampled by different companies, this meant sampling took place at different labs. These results were useful as they confirm the soil test lab results were similar to each other, providing reassurance on accuracy, and providing the basis for management decisions.

2.3.3 Presentation of similar results in different ways can be confusing and expert guidance is helpful

When comparing the presentation of the information from each company (as provided in the maps overleaf), the colour of the zones can be misleading and give a false impression of the results between the two sampling companies, so care has to be taken when comparing results from different companies and the scales used.

The two companies used slightly different scales to each other. Although primarily the same in terms of overall results, the colours and numbers on each were different. Such differences could lead to different comparisons and conclusions, and therefore the colours and numbers need to be understood prior to any conclusion being made.

Company A	Company B
Strategic 	Soil zones 

2.4 Overall project conclusions

The conclusions of the project have been considered in Section 1 and 2 of this report. In summary, the conclusions, as outlined by Ian Beecher, the Precision Mapping consultant used in the project, are as follows:

- Variation was found in both fields from a nutritional perspective for P, K and pH. Variation was also found for soils texture zones compared to the farmer's own understanding of his fields.
- There was no indication which of the 2 sampling systems would be the best method for the farm, as the results were similar. The farmer could therefore select a provider based on the accessibility of information and cost, rather than having to query accuracy.
- The financial benefit of using soil nutrient mapping can only really be established once the full range of variation has been established across the whole farm, then decisions can be made as regards distributing, increasing and decreasing inputs.

- There are environmental opportunities to manage fertiliser more efficiently and placing it in the correct place, at the correct time, for the plant to use it rather than it be washed in to a watercourse.

2.4.1 SWOT analysis

STRENGTHS	Soil Nutrient Mapping: • Provides information that allows for adjustments to be made in fertiliser application rates within single fields • Allows for targeted inputs • Reduces inefficiencies associated with nutrient inputs – improves optimisation • Reduces environmental impacts associated with run off • Reduces economic impact associated with run off and allows financial input where it is needed • Improved accuracy in soil nutrient knowledge across the growing area • Provides improved farm records • Precision farming technology can be linked with farm management software, improving data collection and efficiency in terms of on farm activities
WEAKNESSES	• The only way to understand nutritional variation and whether it exists is to sample comprehensively, and this can often be costly • Individual companies present information in different ways, which can be confusing • Expert advice is required in order to interpret results initially, which has a cost • There may not be any cost savings made in terms of fertiliser use • Initial capital costs may be high, if looking to purchase precision fertiliser application equipment
OPPORTUNITIES	• Fields with the high or low indices can be better managed to improve productivity • Improved environmental management, reducing run off and any additional environmental pollution
THREATS	• Scales used by different sampling companies may not be comparable • Weather conditions may determine the ability to test – wet conditions are not suitable • The ability to act on the information provided relies on either the farmer or contractor having precision machinery, capable of adjusting applications within a field

2.4.2 Alignment to sector's strategic goals

This work contributes to the Agriculture and Food objective of the Welsh Government Natural Resource Policy 2017[3]:

To continue to co-ordinate and embed best practice for the sustainable management of our soil resources. This will be informed by monitoring trends in carbon stock, a better understanding of the soil resource, the functional importance of soil biodiversity, and trends in and management of macronutrients.

The techniques explored and learning arising from the project align well with recommendations outlined in the Code of Good Agricultural Practice for Wales[4].

The project helps this farm, and the wider industry (via dissemination of the learning) contribute to the priorities of the Twenty-twenty Vision action plan for the red meat sector[5], specifically:

Improve production efficiency (thereby increasing quality supply) whilst maintaining the environment and landscape of Wales.

Establish mechanisms that will maximise outputs from grass-based systems and reduce reliance on bought in (imported) feed.

Inform/educate the industry about cost saving and conservation, energy and water efficiency, ways to reduce waste and ways to improve knowledge, openness and transparency.

Deliver new technology transfer activities that can demonstrate practical industry solutions to encourage uptake of new technology.

Deliver knowledge transfer activities that promote innovation and encourage the uptake of best practice.

3 Impact on the industry

3.1 Impact on individual business

This is covered in the Summary section of this report.

3.2 Impact on wider industry

Refer to the Take Home Points for the Industry section in the Summary section of this report.

There is scope for this project concept to be replicated over grass and arable farms throughout Wales. Dudwell Farm is a great example of how soil nutrient mapping can help arable and livestock farmers manage their fertiliser application rates, adjust application rates within a single field depending on nutrient status, and limit environmental pollution risks associated with excess fertiliser applications on those areas that do not require it.

Longer term, the adoption of the combination of crop requirement principles with soil nutrient mapping (i.e. application precision within fields) by the industry more widely should help improve efficiency, optimise farm expenditure and reduce diffuse pollution.

This graph 'Wales Summary of Waterbodies Failing due to Diffuse Pollution. January 2013' relates to the level of diffuse pollution caused by a number of industries.

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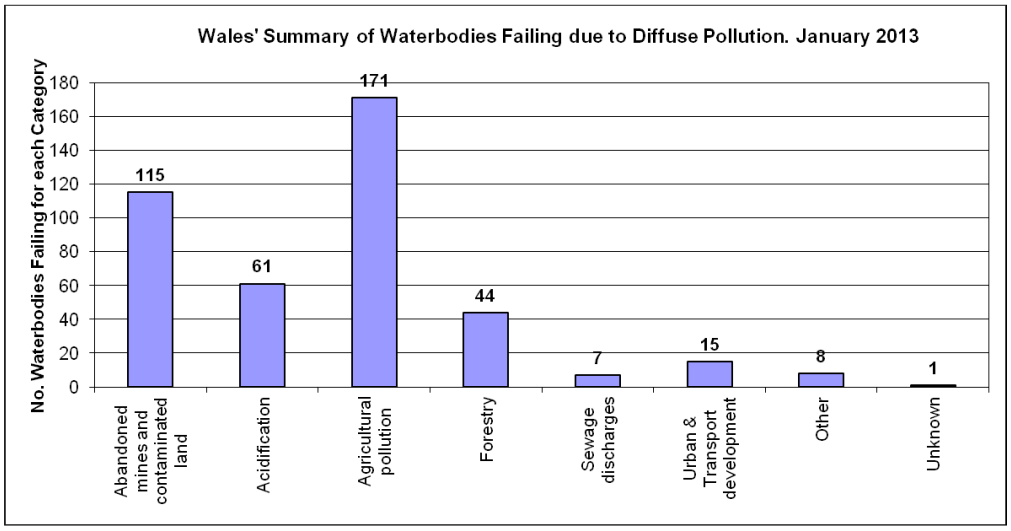
[3] https://gov.wales/docs/desh/publications/170821-natural-resources-policy-en.PDF

[4] https://gov.wales/topics/environmentcountryside/farmingandcountryside/farming/code-good-agricultural-practice-cogap/?lang=en

[5]http://hccmpw.org.uk/about_hcc/corporate_publications/the_strategic_action_plan_for_the_welsh_red_meat_industry



In Wales, agricultural activities can cause significant diffuse pollution problems, if good practice is not followed. The main water quality problems associated with diffuse pollution from agriculture relate to the loss of nutrients such as phosphorus and nitrogen, pesticides and other agrochemicals and faecal microorganisms. Soil erosion is also an issue in some areas, particularly where sloping grassland or river banks are poached, with phosphorus, ammonia and faecal microorganisms associated with the loss of sediment.

Improvements made as a result of targeting inputs via the use of precision technology is likely to reduce the incidence of runoff and diffuse pollution risks.

3.3 Impact on Welsh Government's cross cutting and priority themes

3.3.1 Climate Change

Agriculture is both affected by and contributes to, climate change. Climate change is currently presenting us with production challenges as there is the need to maintain a productive system from as low a carbon emissions base as possible. Effective use of fertiliser will provide soils with adequate amounts of required nutrients to ensure soil nutrient status is at optimum levels to provide desirable conditions to maintain soil quality and result in a productive and efficient system.

Greenhouse gases released along the food production supply chain can be reduced by more effective use of fertiliser, in addition to the improved integration of innovative techniques. Precision farming has a valuable role to play in this.

Precision farming approaches, such as soil nutrient mapping can help to manage crop production inputs in an environmentally friendly way by using site specific knowledge to target rates of fertiliser, seed and chemicals. A tailored, site specific input programme will help reduce losses of nutrients and soil resources into the wider environment.

3.3.2 Animal Health and Welfare (AHW)

Implementing a regular soil assessment and nutrient planning programme on a long term basis should result in an improvement in the standards of the feed and grazing environments for livestock on-farm. Optimising production from crops intended for animal feed (grass or arable), including the achievement of desirable sward heights and pasture covers, should be more achievable when using precise results from soil nutrient mapping.

3.3.3 Future Generations

Addressing the ongoing challenges associated with productivity and the environment will allow young farmers to see that challenges can be overcome in the industry, and precision farming technology plays a part in this.

Targeting inputs via precision farming not only improves on farm productivity but also reduces the environmental risks. Helping farm businesses become more resilient helps provide a more secure business proposition for new entrants/young professionals within the sector.

Such adaptions to challenges should inspire and motivate future generations to pursue or continue a career in agriculture.

Tackling such challenges now, and sharing the knowledge with the wider industry should encourage future generations to adopt new farming methods and technologies, to ensure a better managed and productive business. Such adoption would help to create a more secure future for livestock and arable production in Wales.

3.3.4 Tackling Poverty

Focusing on key elements such as improved productivity and efficiency on farms will reduce the financial strain many Welsh farmers are currently facing. More cost efficient business practices result in the potential for increased returns, with adaption to new technologies likely to be a useful long term sustainable investment.