

ONE Agritech Programme

Digital Crop Production Guide – Part 1 Soil Analysis

Modern arable systems are now producing a significant amount of data whether that be from soil analysis, yield data or satellite imagery. These sources of data can all provide useful insights into your field's performance, but how can this information bring meaningful change on the farm to improve efficiency and productivity? This four-part guide is designed to explain some of the sources of information available to growers and examine where further investigation might be required to make decisions on the farm.

To help with this guide, we have linked up with Scott Campbell, Kirkton of Kinellar, who has been generating significant levels of data from his arable enterprise over the last number of years. Some of his information is used within this guide to show how the information can be used.

Soil Analysis – Chemical

There are many ways in which soils can be analysed from basic W shaped sampling through to soil scanning and zone sampling. When choosing your soil analysis system it is important to research the methodology used for analysis so that it suits your farm and system. This guide looks at the results from AGRII for a field at Kirkton of Kinellar.

pH

The analysis for pH is taken on a one per hectare basis with each result displayed as in figure 1 below. There is then a calculation in the background which determines where the zones are situated which is shown by the changes in colour. This can then be changed into an application map for lime. When this information is uploaded to a GPS enabled spreader the field can then be variably spread to reach the target pH for the farm. In the map in figure 1 the field varies from pH of 6 to 6.7. Therefore, no action to apply lime is required.

There are also sampling systems which take a grid-based approach to pH (see figure 2). This system is either on hectare or quarter hectare grids which give a greater intensity of sampling and better repeatability over time. Figure 2 is an example of grid sampling used on another farm and produced by Soil Essentials.

Phosphate

In figure 3 the soil analysis has been taken on a 1 per hectare basis and the map is calculated in the same way as pH. The type of analysis used is also important with the Modified Morgans analysis preferred in Scotland, due to more acid soils, which will give a more accurate phosphate result. Historical cropping, application of FYM/slurry and amalgamation of fields can have a large influence on soil phosphate and often these variations can be found in these maps.

The phosphate map in figure 3 highlights that the status is all in the moderate category, which is the target status for this farm. There is therefore no need for additional phosphate to be applied above crop requirement.

P
Below 10 - Very Low
10 - 25 - Low
26 - 50 - Mod-
51 - 75 - Mod+
76 - 100 - High
100+ - Excessive

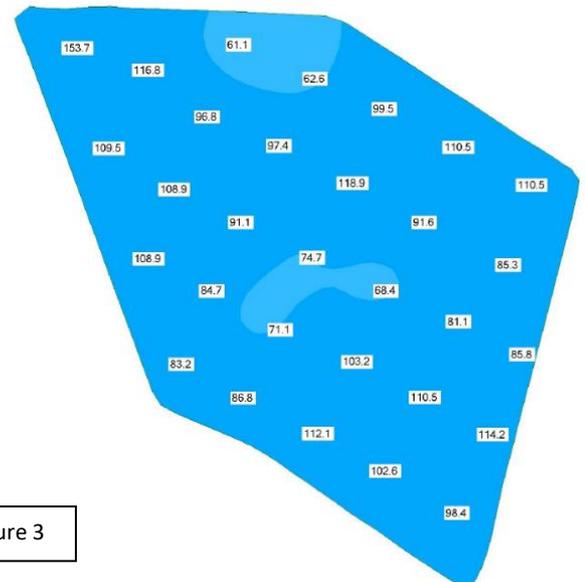


Figure 3

Potash

The potash map in figure 4 has been created based on one sample per hectare and the zones calculated in the same way as for the phosphate map above. Soil potash levels can also be heavily influenced by the previous cropping, amalgamation of fields and application of FYM and slurry.

The potash map on the right shows the status is all in the moderate+ or high status. In this case the field is at the higher end of the target status and there may be the option to reduce fertiliser applications to take advantage of this higher nutrient status. Variable rate application could also be used here to balance crop potash

K
Below 40 - V.Low
41 - 75 - Low
76 - 135 - Mod-
136 - 200 - Mod+
200 - 899 - High
900+ - Excessive

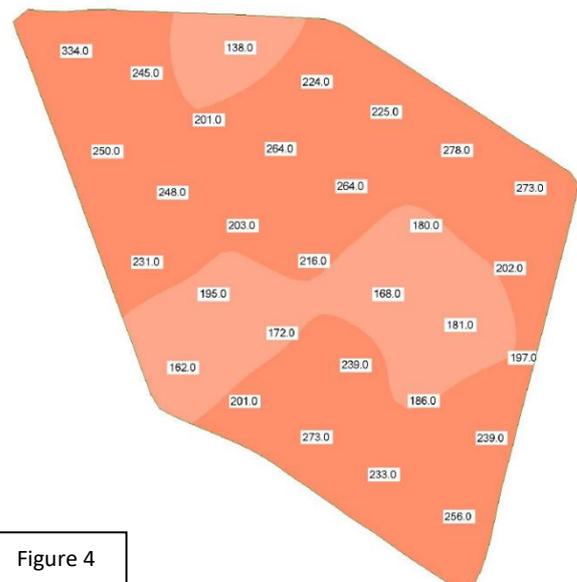


Figure 4

requirements.

Soil Analysis – Biological

Organic matter

Soil organic matter analysis is a more recent addition to soil analysis and a requirement for Preparing for Sustainable Farming (PSF) and Whole Farm Plan (WFP). There are two main commercially available techniques of measuring organic matter in soil. The first is Loss on Ignition (LOI) which involves measuring the weight loss after heating a sample to a high temperature. The second technique is Dumas which measures the carbon dioxide released from a sample during heating. This method is considered a more reliable measurement of organic matter content than LOI.

Organic matter content in soils is one of the key drivers of plant nutrition and growth and needs to be managed. It is more regularly measured on a per field basis rather than using GPS sampling to give an indication of field levels. If levels are low then management practices such as chopping straw, applying FYM/Digestate and compost or growing cover crops can all help to improve organic matter levels.

Soil Health

There are two main commercial tests available for measuring the health of your soil. Below is a guide to these tests.

Test	Description
CO ₂ Respiration	<ul style="list-style-type: none"> Measures activity of soil microbes Also known as a CO₂ burst test Provides an estimate of the soil microbial biomass Results vary depending on weather, soil temperature and soil moisture
Potentially Mineralizable Nitrogen	<ul style="list-style-type: none"> Measures the organic nitrogen in the soil that can be converted into plant available inorganic forms (like nitrate and ammonia) through microbial activity Results are influenced by soil texture, moisture, temperature and soil management history

These tests give a guide to microbial activity at the time of sampling and really need to have results covering a number of years to allow management decisions to be made.

Soil Analysis – Physical

The measurement of soil physics requires several different techniques to give a rounded appraisal of your soil. The first is to get a spade and dig a hole and look at the soil profile and where there may be compaction or poor soil structure. An excellent guide to this process is available here <https://www.sruc.ac.uk/media/xbrfn4x3/vess-colour-chart.pdf>

Another more scientific way of measuring soil physics is by measuring the water stable aggregates (WSA). These are clumps of soil particles bound together by organic matter

and microbes which form stable “crumbs” of soil which are resistant to breakdown by water. These are good for soil health and provide aeration, water infiltration, nutrient retention and help prevent erosion. A high WSA figure indicates a healthy soil structure which will benefit crop production.

What to do with soil analysis information?

The main actions from soil analysis are:

- correct any deficiencies starting with pH then the other major nutrients.
- reduce any fertiliser applications if soil status is becoming too high.
- target FYM/slurry to fields that are deficient.
- look at longer term trends in status and whether enough or too little fertiliser is being applied over the rotation.
- Is there enough variation in the fields to warrant spreading phosphate and potash variably?
- Do I need to alter my rotation to bring in more diversity and improve soil health?
- Can cover crops be introduced to keep soils protected and improve soil health?
- Should you be adding additional testing measures to your soil analysis to give you a better understanding of your soil.

For additional information about the soils that you farm then there is a huge amount of information available at the following link <https://soils.environment.gov.scot/maps/soil-maps/national-soil-map-of-scotland/>. This is especially useful when there are changes in soil type within a field and gives details of the soil's natural fertility, drainage and carbon content. This adds an additional perspective to a routine soil analysis.

Digital Crop Production Guide –

Part 2 Yield Data

A lot of modern combines now can yield map. The information generated from the combine gives an accurate representation of how the field has performed in that season. To the right (see figure 5) is the yield analysis map for the same field when it was in winter wheat. The map shows the variation in yield within the field with the greener areas showing the higher yielding areas and the red the poorer areas.

In some cases, this map can tell you some of what you already know, in identifying the poorer areas of the field. However, sometimes it gives an insight into areas that are maybe not be visually poor but have an underlying problem. For example, in this case there is a definite reduction in yield on the endriggs and the north part of this field, shown by the increased red areas. This could be for a number of reasons such as:

- compaction
- drainage
- rainfall
- surface water runoff
- topography
- summer sunshine

The information in the map above can be adjusted once the final weight and specific weight of the crop is known. This is required if the data is to be used for variable rate fertiliser application. However, knowing the variation can be just as useful in some cases.

Variable rate fertiliser

Using yield map data to generate variable rate fertiliser can be a good way of reducing costs and variability within the crop. The yield map from the previous crop can be used as the reference for calculating the offtake of P and K. This information is then used to create a spreading map to be able to spread separate P and K products. Using this technology allows the P and K status of the field to be less variable and for the correct amount of product to be applied where necessary. For Nitrogen fertiliser it is more likely that satellite imagery would be used for variable application.

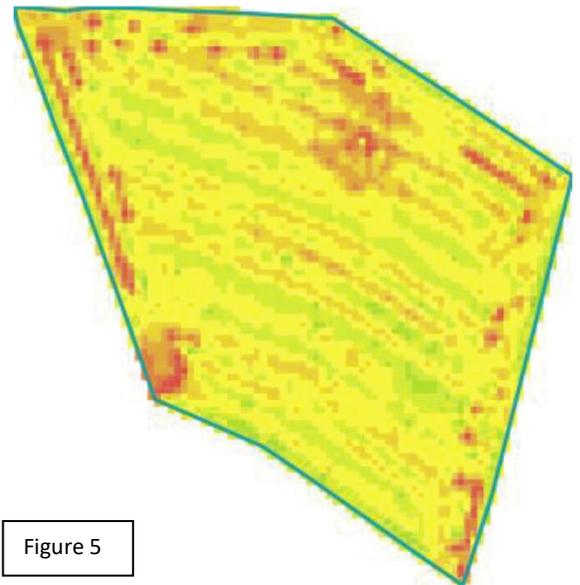


Figure 5

Digital Crop Production Guide – Part 3 Satellite Maps

Satellite mapping of crops is becoming more available to growers as technology advances and the costs of these services reduce. These maps provide another insight into crop growth during the season.

Satellite imagery is available on many digital farming platforms. Images are available every few days but are dependent on the weather conditions as to how clear they are. The satellite image is used to measure the “greenness” of the field using Normalized Difference Vegetation Index (NDVI). Figure 6 to the right is taken from the 16th of April when the crop is starting to develop after the winter. The second image (see figure 7) is taken on the 13th of May when there is a significant difference in the canopy of the crop.

These images can be used in two main ways:

Firstly, to identify any parts of a field that are not performing, perhaps due to disease or nutrition and may need investigation. These areas cannot often be seen by eye in the field.

Secondly to produce a variable rate nitrogen map to apply more nitrogen to areas of the field which are not performing in the spring and to try and reduce the variability in the crop. Later in the season applications then change to apply more nitrogen to the good areas to maximise the potential from these areas.



Evaluating Field performance

The map below has been generated using Soil Essentials' Kore system and shows the Harvest Predicted Index (HPI). HPI can be generated for a single year or for a number of years. It is created by layering the NDVI satellite images taken during the season for a field to show the variation over time. This can then be completed for a number of years with differing crops. It is very useful for identifying specific problems over time that are not crop specific. It is important to think about the weather in the production year as in a wet year, the better performing areas might differ when compared to a dry year.

In the map to the right (see figure 8) the green areas are the better areas, and the red areas are poorer areas. The map highlights a lot of the same areas as the yield map especially around the endriggs. The area that has appeared in the HPI map is the area running North to South within the field. This is not particularly visible in the yield map, but when discussing this with Scott, it was highlighted that a gas pipeline was laid through this area in the 1980's. This is obviously still having an effect on crop production decades after construction.



Variable seed rates

A multi-year HPI map is a useful starting point to generate a variable seed rate map. Due to the way it has been created, the map shows all the areas that are poorer performing. This can then be used to create a seed rate map with the poorer areas getting more seed and the better areas the normal seed rate or slightly less. This makes best use of seed but also allows areas where establishment is perhaps the problem to improve performance.

Digital Crop Production Guide – Part 4 How do we use the data?

With the sources of field data described above you can now start to build up a picture of how each field is performing and where there may be areas that require additional investigation. Below are a few scenarios which show how the data above can be used to diagnose the most likely problem and a plan put together for improvement.

Scenario 1

Poor areas around headlands showing reduced yields on yield maps. Satellite maps also show variation on the same areas throughout the season. Digging a hole in the poorer areas shows a layer of compaction at 10–12 inches and poor soil structure.

Below are some thoughts on ways to help improve the poor areas:

1. Subsoil below compaction layer if soil conditions allow
2. Chop straw on headlands to feed soil and add organic matter improving soil structure over time.
3. Increase seed rates around headlands by approx 10% to allow for greater spring plant population
4. Investigate drainage/ditches around field to make sure drains are clear and not causing saturated soils

Scenario 2

Poor area of growth shown on the satellite map but not showing up on the yield map for that year. Previous years yield maps show poorer yields in some seasons. This would suggest a drainage issue with fields performing well in a dryer year or poorer in a wet year. This could be down to soil type.

Below are some thoughts on ways to help improve the poor areas:

1. Check there are no utilities (electric, gas, water, sewage) pipes or cables in the poor areas which are suffering poor yields due to damaged drains, or the mixing of subsoil and topsoil. This can still be a problem decades after construction. Is there compensation from utility company due? Can the yield maps quantify this?
2. Check field drains/outlets to make sure water can flow freely.
3. Dig down to drains and see if water is getting to them or for any blockages etc
4. Perhaps restone drains to allow water to flow more easily and draw water.
5. Are drains at the end of their life? Do they need replaced?
6. Does the soil need a rest and chance to restructure?
7. Would a green manure or cover crop help to improve overall soil health?

8. Is it just natural variation within the soil type in the field? Would using variable rate seeding or nitrogen application be of benefit to reduce the variation in the growth during the season resulting in less variable yield?

Scenario 3

Over a number of years, a headland has not performed, confirmed by the data on the yield maps. From satellite maps the field is also showing consistently poor results. Soil analysis does not show any particular pH or nutrition problems. Soil data shows it is a naturally imperfectly drained soil and due to topography, is unable to be drained.

Below are some thoughts and ways to maximise these areas:

1. Unlikely that even if the soil could be drained that it would make a big difference due to the soil's imperfectly drained nature.
2. Are there any schemes that can be used to take advantage of this area? Options such as EFA (margins, fallow, hedges, unharvested crops, herb and legume rich pastures, agro forestry) AECS, woodland planting or grassland. Will any of the above help the problem or just push the issue further into the field?

Conclusion

There are now several different sources of data available to the arable farmer that when combined can be used to inform decision making on farm. Often this data is there but underutilised and for this to have impact on farm, there is a requirement to investigate further and try different ideas or techniques to improve farm profitability.

As farmers it is assumed that you know your soils, but soil and cropping mapping tools can help show unidentified problems and understand the reasons behind those problems. New technology is bringing easier to use tools to help you do the measuring and without the base line data it is difficult to know if improvements are being made.

Your soils underpin your farms production; therefore, your understanding is critical especially tracking trends for example in organic matter content over time. This may become even more critical in the future with changes in agricultural policy.

Using the data generated through targeting of inputs whether that be lime, fertiliser or seed give almost immediate gain in both saving costs and improving yield.

Finally, is it important to have a methodical approach to make the best of all the data that can be generated. Soil sample frequently at least every 5 years. Measure and map at gross scale to identify any issues, follow up on the ground (get the spade out), identify the causes, select the practical solutions and monitor the impact. Taking this approach will make sure you maximise the return on your investment in this technology.