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Targeting precision in crop management

Key external stakeholders:

- Crop growers,
- Advisors/Agronomists,
- Researchers,
- Policy makers

Practical implications for stakeholders:

There is potential for a more targeted or precise approach to crop production, however there are challenges to be overcome before variable rate input application technologies can be profitably exploited on Irish farms.

- While there is potential for spatially variable management, there are still challenges in predicting what the variable response should be.
- Simple approaches to crop variability assessment and management are viable.
- While the technologies are available to acquire and process reflectance crop data, using this data profitably remains a challenge
- Precision Agriculture technologies need to be critically examined to determine if benefits outweigh their costs in specific farm situations.

Main results:

- Historic yield maps from combine yield sensors are a good source of in-field variability data but high resolution satellite reflectance imagery may be substituted if combine maps are not available.
- The potential for a spatially variable management approach was illustrated by different responses to disease control and nitrogen application; in high and low yield potential areas, at two trial sites.
- The soil sampling resolution required to give adequate information, as a basis for spatially variable nutrient application, varied between sites indicating the need for higher resolution sampling systems.
- A simple tool box approach to determining and analysing variability within fields was developed.
- The use of drone acquired crop reflectance data and on-line processing tools was found to be feasible, but the resulting variable N application did not produce any production or N sparing benefit.
- Cost/ benefit analysis shows that some machine guidance technologies are cost effective today.

Opportunity / Benefit:

- There is scope for adopting spatially variable management approaches, however predicting the correct response is not necessarily possible today.
- Simple tools and techniques can be used to commence a more precise management approach based on identifying zones of difference and factors causing that difference.
- Guidance technologies can be exploited to improve machine efficiency and input application.

Collaborating Institutions:

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1. Project background:

The concept of precision agriculture, and specifically that of implementing spatially variable management rather than treating entire fields as one, has been in existence since the 1990s. At the start of this project adoption by growers in Ireland was relatively poor with uptake largely limited to machine guidance systems. While some had adopted a spatial approach to soil analysis and subsequently applied P and K fertilizer on a spatially variable basis, the practice was very limited. Only one or two growers used crop reflectance to assess N demand and while a considerable number of combines had yield meters fitted, the use of yield maps to influence in-field decisions was limited to a couple of growers. This cautious approach to adoption was in part influenced by the lack of clear indicators from research about the benefits of adopting this technology. While interest in precision agriculture approaches among researchers, technology developers and growers has increased significantly in recent years, a response is required to inform growers about these technologies and that demonstrates their potential on Irish farms. The aim of this project, which was part of the BETTER crops programme, was to assess and demonstrate to growers a more precise crop management approach driven by sensing, positioning and control technologies, that will in the future allow production to be optimized.

2. Questions addressed by the project:

- Is there potential to optimize production by applying different management approaches to areas of different yield potential?
- What level of variation in soil analysis is typical within tillage fields and what sampling intensity is required to adopt a spatially variable approach to fertilizer application?
- Is there a role for existing crop reflectance approaches to improve N targeting on cereals?
- Can a relatively simple approach to investigation of yield variation be adopted?

3. The experimental studies:

As part of the BETTER farm crops programme, this project focused on demonstration and dissemination in addition to validation research and consequently had a number of components.

On three of the BETTER farms, fields were examined for variation in yield potential using a combination of previous yield maps (two farms), historic satellite NDVI imagery with 5m resolution (all farms) and soil electrical conductivity characteristics as measured by EM38 sensor. On two of the three fields, a combination of three disease control strategies and three N applications were applied in a randomized block design to identify high and low yield potential areas and all crop parameters were measured to determine if there was a different response.

In a separate study on the same three test fields, the need for sampling intensity was evaluated by adopting a grid approach to soil sampling and acquiring one sample per 25m x 25m grid. These samples (16 per hectare) were analysed for nutrient content and proxies for sampling at lower resolutions were achieved by combining the results to give resolutions equivalent to a grid of 50m x 50m, 100m x 100m, 200m x 200m and a sample per 4ha using a W shaped sampling pattern.

A crop variability analysis toolbox (steps to managing variability) was developed to aid the management of variability within fields. This included a number of methods of assessing variability and identifying possible causes based on crop, soil and topography observations and measurements. A zone approach to crop management could then be applied if areas of difference were noted. The toolbox method was applied to test fields in the three BETTER farms and crop performance was monitored in assigned zones along with soil nutrient analysis and soil structure assessment using the VESS visual assessment method.

Crop reflectance as measured by multi-spectral sensors can be used to predict the nitrogen content of the crop and the amount of biomass present and consequently can be used to indicate the amount of N required on a spatially variable basis within a field. To evaluate this technology, areas in each of the three farms were scanned using a drone-mounted reflectance scanner and a commercial service (Airinov) was used to process the data and to provide N application recommendations on a spatially variable basis. This N

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recommendation was applied with spreaders with variable rate capability using a downloaded application map.

With many growers evaluating the purchase of guidance/autosteer systems which enable improved accuracy with input application, a costing exercise was also carried out and break-even areas calculated based on input savings.

4. Main results:

Both historic yield maps and satellite reflectance imagery that yielded NDVI (biomass related vegetation index) maps were capable of highlighting areas of yield potential difference within fields. However, seasonal weather could impact on the result, with for example a light textured free-draining soil zone yielding better than average in a wet year, but poorer than average in a dry year; consequently a history of yield maps and weather data gives a lot more information than one year. The single year's electrical conductivity data gave very little useful information on soil zone difference and was not utilised in our studies.

The evaluation of different management regimes on areas of high and low yield potential indicated the potential for a spatially variable approach. On the winter barley trial site, there were clear interactions between the yield potential of specific areas in the field and the response to inputs with the high yielding area responding strongly to increased disease control measures giving a 1.5 t/ha response versus 0.7 t/ha response on the lower yielding area. However, the low yielding area gave a much higher response to increased N application at 1.2t/ha compared to just 0.4 t/ha for extra N applied to the high yielding area. On a spring oats trial site a similar difference in response to N application between high and low yield potential sites was also achieved.

The soil analysis sampling indicated substantial variation in nutrient levels within the three test fields despite all three of the farms having active soil sampling regimes. There was however a difference in the requirement for resolution across the 3 sites. Sites 1 and 2 would have benefited modestly from adopting higher resolution sampling with a > 75% chance of any of the sampling regimes giving values within 5mg/l of the value measured at 25m grid. However, the third site results indicated greater variability that resulted in any of the sampling regimes at lower resolution than a 25m grid, giving a poorer representation of the variability with only between 34% and 51% chance of these values being close to the true value. This is quite a challenging result as it indicates that different sites require different sampling resolutions to manage variability. Of most importance, this underlines the importance of having less expensive soil analysis methods to enable greater sampling resolution.

The use of the toolbox approach for investigating variability within fields has the potential to identify areas of difference, with the zones assigned in the test fields having different soil structure quality scores and different pre-harvest crop structures. Yields varied by 23%, 16% and 22% between zones on the three farms. Yet, while there was some association between soil structural quality and yield, it did not explain all of the variation.

The application of a commercial crop reflectance scanning approach using a drone-mounted sensor and on-line analysis service proved successful in measuring crop variability in terms of estimates of N uptake and crop biomass. The provision of a variable rate N application map was successful from a technical aspect allowing different rates of fertiliser to be applied to designated parts of the test fields. However when subsequent yields were measured, there were no significant yield differences recorded. The algorithms used to determine the response were from a different climate and not optimised for Irish conditions.

A simple costing spreadsheet was prepared to evaluate the costs and benefits associated with machine guidance and auto-steering. A range of costs and breakeven areas for a number of systems were calculated illustrating that auto-steering and automated headland (section) control of sprayers and spreaders are viable options on many tillage farms.

5. Opportunity/Benefit:

- The opportunity for future exploitation of spatially variable management has been demonstrated by the results of the variable inputs trial on areas of high and low yield potential. However, further work is required to identify the most robust and efficient management approach relevant to the crop and/or soil type in question.

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- The evaluation of a commercial crop reflectance scanning approach illustrates that the concept of drone acquisition of reflectance data followed by on-line processing and subsequent variable rate application, is technically feasible. However the information used to determine the response is not optimised for Irish cereal production.
- The adoption of a more precise approach to crop management by investigating areas or zones of difference is likely to yield some short-term benefits and will get growers prepared for adopting more targeted approaches to crop management, as proven systems become available.
- The development of less expensive soil analysis techniques which will allow higher resolution sampling is necessary to ensure future reliable variable nutrient application based on soil analysis.
- The use of current or historic satellite reflectance data may prove useful in determining zones of variability in fields where combine yield maps are unavailable.
- Cost/benefit analysis of technology is essential and illustrates that precision agriculture technologies associated with machine guidance and machine control can be exploited profitably.

6. Dissemination:

The main dissemination mechanism used for this project was a series of BETTER farm open day events along with other group dissemination activity including:

Event 1: BETTER farm event Waterford, Feb 2016
Event 2: BETTER farm event Carlow, Feb 2016
Event 3: BETTER farm event Carlow, Sept 2016
Event 4: FTMTA farm machinery show, Feb 2017
Event 5: Crops open day, Oak Park . June 2017
Event 6: BETTER farm event Waterford, Sept 2017
Event 7: BETTER farm event Carlow, Sept 2017
Event 8: BETTER farm event Dublin, Sept 2017
Event 9: BETTER farm event Waterford, June 2018.
Event 9: BETTER farm event Carlow, June 2018
Event 9: BETTER farm event Dublin, June 2018

Main publications:

Ward, M. (2016) ‘ A study of soil variability in three Irish tillage fields and the impact of variable management strategies on crop spatial yield potential’ *Masters thesis submitted to UCD*.
Anon (2015). EIP-Agri Focus group Precision Farming, *Contribution to final Report*
https://ec.europa.eu/eip/agriculture/sites/agri-eip/files/eip-agri_focus_group_on_precision_farming_final_report_2015.pdf

Popular publications:

Forristal, D. (2017) Costs and benefit estimates of precision agriculture systems. Advisory technical note, Teagasc, Carlow.
Forristal, D. (2016) Precision Agriculture, great technology but choose wisely. Irish Farmers Journal, June 22 2016.
Forristal, D. Burke, B. (2016) High precision field trials. T research vol 11 n1 p22-23.

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