Final Project Summary

Project title	Exploiting yield maps and soil management zones		
Project number	RD-2012-3875	**Final Project Report**	PR565
Start date	01 January 2013	**End date**	31 December 2015
AHDB Cereals & Oilseeds funding	£202,308	**Total cost**	£206,508

What was the challenge/demand for the work?

Yield mapping on British arable farms has been possible since the early 1990s, and coupled systems of yield monitors and global positioning systems are now routinely fitted on many makes of combine harvester. This means that farmers are gathering a plethora of data on the variation of yields within their fields, but it is not clear how it can be fully exploited for management decisions. The additional issue is that the yield monitor data often contains artefacts which must be removed before it can usefully be exploited.

How did the project address this?

We reviewed the current literature and found three programs for cleaning yield monitor data that are freely available to farmers. We also developed our own program (ROTH YE) for cleaning yield monitor data. Our program includes a novel method for dealing with the delay between the crop entering the harvester and its flow (which is used to estimate local yield) being recorded by the sensor (Fig. 1). We evaluated all four methods and found that two of them were not suitable for UK conditions because they used a geographical projection that warps the shape of fields and so gives erroneous results. The third method (developed in the AHDB Cereals & Oilseeds Auto-N project) worked well but did not have an easy to use interface. Our program (ROTH YE) proved to work as well as, or better than the other methods we reviewed and is straightforward to use.

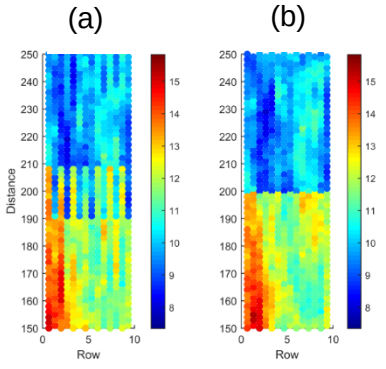
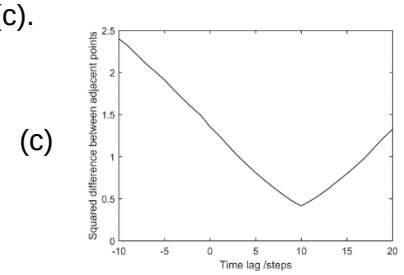


Figure 1. Examples of maps showing the effect of flow delay before (a) and after correction (b) and the time shifts applied in terms of the squared difference between points and the time lag (c).



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Some approaches use yield monitor data to simply partition the field into areas that constantly yield better than average, consistently poorer than average or lie somewhere between. Such strategies are based on the assumption that permanent characteristics of soil always lead to the same behaviour in each year. However, often the average yield for a particular area of the field fluctuates between seasons depending on weather, management and variation in the factors that limit yield. Therefore, if one wants to understand the observed variation in the field, algorithms based on understanding the processes that account for both within field and year-to-year variation are better. We show that smoothed fuzzy k-means cluster analysis is ideally suited to delineate management zones within fields where the points within zones vary similarly to one another across seasons. In practice identifying management zones in this way is useful for the farmer as it highlights and quantifies differences in yield that should be explored further. By understanding the causes of the differences, the farmer will be able to manage his or her fields more effectively.

Generally, fertilizer application rates (uniform or variable) are decided based on soil sampling results. The average soil nutrient concentration within a reasonably uniform area can be established by measuring at 10-15 locations on a 'W' design across the area and bulking the samples before analysis. However, it is not clear how a farmer should establish when the nutrient concentration within a field is sufficiently uniform to follow this strategy, or whether it would be better to divide to field into smaller management zones and measure the nutrient status in each, or even to vary nutrient inputs at the finest scale permitted by the fertilizer spreader. For this latter approach, the farmer needs to understand the inherent variation of the nutrient in the soil which requires a more intensive sampling strategy such as grid-based sampling. Each method of sampling brings with it cost implications and so the best approach will vary from field to field. We have demonstrated that the variation within yield maps can be used to indicate which of these sampling strategies is likely to be most profitable. For example, if the variation in yield is small then it is unlikely that variable rate fertilizer management will be worthwhile, whilst if the variation is at a scale too fine for management then effective variable rate management will not be possible. In these cases a field based estimate would be sufficient.

We also explored to see if the spatial variation captured in the yield monitor data could, in general, help to determine whether spatially variable management is cost effective. We considered two methods for doing this reported in the literature. We found problems with both methods and so proposed a new metric for variable rate management that we demonstrate can be used by farmers to rank their fields according to the potential for variable rate management.

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What outputs has the project delivered?

- We have developed a robust algorithm for cleaning yield monitor data that is appropriate for UK farmers.
- We have determined a sound methodology for delineating yield management zones using yield monitor data.
- We have shown that yield monitor data can be used to inform on whether grid-based sampling or zone-based sampling for soil nutrients are likely to be more profitable than field-based sampling.
- We have developed a metric for farmers to rank their fields based on the potential for variable rate management.
- We have produced guidance for farmers on how to process their yield monitor data. However, to fully exploit this, farmers need access to the algorithms that we have developed in the form of user-friendly computer programs.
- We have one scientific paper in review, and we have presented two posters based on our work.

- Muhammed S. E., Marchant B.P., Webster R. D., Whitmore, A. P., Dailey, G., Milne, A.E. (submitted). Comparing sampling designs for managing fertilizer practice. Computers and Electronics in Agriculture.

- Muhammed, S.E., Milne, A.E., Marchant, B.P., Griffin, S. and Whitmore, A.P. Exploiting yield maps and soil management zones. Poster presentation in the agronomic conference of the International fertilizer Society in Cambridge during 11-12 December 2014.

- Muhammed S. E., Marchant B.P., Webster R. D., Milne, A.E. Dailey, G., Whitmore, A. P. 'Uncertainty in the profitability of fertilizer management based on various sampling designs.' European Geosciences Union conference, Vienna, 2016.

Who will benefit from this project and why?

Farmers and advisors will benefit from this project because they will be able to exploit better the yield monitor data, that they collect as standard, to improve their profitability. We have demonstrated that

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yield maps can be used to highlight and quantify differences in yield that should be explored further. Yield maps can also be used to inform on which soil sampling strategy is likely to be most cost effective and to help the farmer determine which fields are likely to most benefit from variable rate management.

Exploiting yield maps and other sensor data is a global challenge with many interested stakeholders and academic beneficiaries. Our research will be of direct interest to scientists in agricultural science.

Improvements in precision farming not only benefit the profitability of farming but also has the potential to reduce pollution of ground waters and emissions of greenhouse gases.

If the challenge has not been specifically met, state why and how this could be overcome
The project objectives have been met. However, to fully exploit the guidance produced for farmers on how to process their yield monitor data, farmers need access to the algorithms that we have developed in the form of user-friendly computer programs.

Lead partner	Rothamsted Research, Harpenden Hertfordshire
Scientific partners	British Geological Survey, Keyworth, Nottingham
Industry partners	SOYL, Newbury
Government sponsor	