The field trials (4 years of data) confirmed that the N-Pilot® advice is relevant and precise: the recommendation for spreading / not spreading is appropriate (based on the analysis of 45 situations)

N advice	Trigger by N-Pilot	No trigger
Need	93%	8%
No Need	14%	86%

2) From a scientific tool to a friendly user advisory tool

The ergonomy of the N-Pilot® was a concern: as it is to be used by farmers, the use of the tool has to be intuitive and attractive.

A dedicated smartphone application and web site have been developed enabling traceability (with a recording of the measurements) and geo-referencing of the diagnostic in every plot.

The objective for the tool was also to provide a recommendation immediately after the measurements, without the need for any connection to an external database. The operating principle was consequently established so that no internet connection on the field is required. All the data is stored on the smartphone. The connection between the N-Pilot® box and the smartphone is created via a Wi-Fi network by the box itself.

The tool has been tested for two years (2013 and 2014) before its commercial launch under real conditions of use to check if it fits with the user's expectations: in 2014, 330 plots representing 3,800 hectares were covered by the N-Pilot® through this validation phase. A satisfaction survey was done at the end of the first year of test, as part of a continuous improvement process. This posed questions covering the perception of the relevance of the advice, advantages and disadvantages, and the ergonomy of the device.

The payback of the tool has also been calculated and is achieved due to the nitrogen savings and the optimization of the yield and protein content. In summary, by an improved NUE.

Conclusion

An efficient use of fertilizer means a positive return for the farmer but also for the environment. The use of N-Pilot® is a valuable contribution for the implementation of the European Nitrate Directive which encourages minimization of the environmental impact of fertilizer while keeping a productive and qualitative, harvest orientated approach for the farmer.

Borealis L.A.T is now promoting the use of this tool in France, Austria and in Hungary. In the coming years additional countries will distribute this tool. New crops are also under development to increase the breadth of its usage. The soundly based knowledge of this technology allows us to start calibration work in other crops like oilseed rape or potatoes.

Exploiting yield maps and soil management zones

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Summary

Yield monitors and global positioning systems fitted to combine harvesters make it possible for farmers to collect information on the variation of their yield within fields. This information, combined with knowledge of soil, can inform site specific crop management strategies where fertilizer, pesticide and other inputs are varied spatially within fields. Our aim is to produce clear guidelines on how to use the yield monitor data to divide the field into relatively homogeneous regions (management zones) to enable farmers to devise variable management practices for each zone. The objectives of our study are i) to devise robust protocols for processing yield and soil information to delineate management zones ii) compare the merits of measuring the variation in soil nutrients using either (a) management zone or (b) regular grid sampling iii) assess the extent to which yield maps can be used to manage soil variation at the scale of soil management zones.

We collated yield and soil data for several fields on a farm near Newbury for the years 2001 to 2011. The soil data included phosphorus and potassium measurements done at 24–36 locations in each field. The yield data, which often contain artefacts, were cleaned with a set of robust filters before they were used to assess the within-field variation. Yield ranges of raw yield data were reduced after cleaning the data by removing the suspect values. We used spatially-weighted cluster analysis to divide the fields into several management zones. The number of zones was determined by the normalized classification entropy (NCE) of the yield data, which is a measure of how different the zones are from one another. Once the management zones had been identified, the next step was to identify the likely cause(s) of yield variation that had resulted in different response zones. In some cases this was clear and so also was the management strategy, but in other cases it may be prudent to take soil samples to learn more about the factors that limiting yield within each zone.

It could be cost-effective to vary management practices such as fertilizer application in two different ways: either between zones or continuously across the field. Farmers who adopt such strategies will require predictions of the soil properties at a fine scale. For estimates of nutrient concentrations in each zone, a number of soil cores should be taken from across the zone and bulked for analysis. If one wishes to predict the continuous variation of a nutrient concentration across the field then it is advisable to sample the soil on a grid and then to use a method such as kriging to predict the nutrient concentration across the field. The sampling effort needed for these predictions will be more costly and laborious than that required to estimate the average value in each zone or a single field average. By simulating nutrient concentrations across the whole field using statistical models of soil variation, we compared the cost-effectiveness of using (i) a field average (ii) zone based averages and (iii) grid based sampling to predict nutrient concentrations and so inform on fertilizer application.

The fields we have studied so far showed little variation in nutrients between zones because they were managed effectively in the past. That means a single nutrient estimate for the whole field was sufficient to inform the fertilizer application rates in these examples. To understand the role of spatial variability of a nutrient within a field in soil sampling, we reduced the mean nutrient concentration in one of the zones in our simulations by 25%, 50% and 75%. With a larger variation in nutrient concentration across the field, it was more cost effective to estimate the nutrient concentration in each management zone or use measurements from a grid sampling scheme to predict the variation across the field, and then adjust the fertilizer rate accordingly. Initial results suggest that the scale and magnitude of the yield variation influences the type of sampling scheme that should be used to estimate nutrient variation.