AGRONOMICS: ENABLING FIELD-SCALE CROP RESEARCH

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Introduction

The challenge facing agriculture of producing more whilst impacting less is real and immediate. For success it is crucial that researchers, farms and the supply chains engage effectively. Knowledge exchange must become a multi-way process including increased interaction between the researcher and the farmer. Thus far, any extrapolation between small (science) and large (industry) scales has entailed large untestable 'leaps of faith'; the two communities have worked at different scales, with different concepts for the analysis of crop performance and different standards of proof. We contend that what is needed is a shared interest in the challenges and constraints faced in the field.

ADAS recently established an 'Agronōmics' initiative to develop common concepts, metrics, targets and techniques that could enable joint analysis of crop performance – in terms of both productivity and sustainability – by farmers and researchers. Traditional crop research employs experimental designs that minimise effects of uncontrolled environmental variables so that responses (e.g. in yield) to controllable inputs (seed, tillage, fertilisers, pesticides) can be tested. However, the area of these small plot trials commonly restricts their relevance to one site and, while their small scale may optimise internal precision and accuracy of the test, it limits wider relevance of the results.

We propose that, over and above the scientific challenges at lab scale, there are big opportunities for science in investigating the multiple variables and emergent properties affecting translation between small and large scales; not least amongst these are the interactions between agronomic innovations – new germplasm, chemistry or machinery – and soil. Research is needed to understand such interactions but current dependence on small-plot trials generally proves inadequate for this because 'sites', even if there are many, confound many factors with soil, especially climate and farming system. However, technologies for on-farm automation ('precision farming') now provide opportunities for quantitative phenotyping at field and farm scales, and also (critically) they provide new understanding of spatially variable factors, particularly soil.

We have identified five key challenges necessary to support an 'Agronōmics' approach: (i) acceptance by farmers and scientists of common concepts for explanation of crop performance, such as 'resource capture'; (ii) motivated and co-ordinated networks of farms that embrace regional and landscape dimensions; (ii) more precise and accurate farm machinery; (iii) new spatially-referenced statistical techniques for modelling and testing on-farm data at intra-field scale; and (v) facilitating software.

Materials and Methods

A farm research network was developed called 'LearN' to study nitrogen (N) nutrition of wheat. Conventional and tramline trials were established on each farm testing standard, low (-60 kg ha^{-1}) and high (+60 kg ha^{-1}) rates of fertiliser N. Through ADAS's Agronōmics Project, tramline trials were supported by detailed treatment and harvesting protocols, bespoke software, and spatial statistics that enable location-specific establishment, treatment and harvesting of sub-tramline areas, transfer and storage of data in standard format, data cleaning (to remove outliers), identification of combine run, direction and position, correction for time lags and GPS drift, location of treatments and wheelings, and calculation of means and variances for combine runs, tramlines, and sub-tramline blocks. 'Spatial Discontinuity Analysis (SDA)' was devised (Rudolph *et al.*, 2016) to test differences across a treatment boundary, and whether these varied longitudinally i.e. due to soil.

Results and Discussion

Yield maps of example tramline trials are shown in Figure 1. Spatial variation within fields was generally larger than the effects of imposed treatments. SDA showed effects at tramline scale to have detection limits between 0.05 and 0.8 t ha^{-1}, dependent on the quality of the yield data and the unmodelled spatial variation. The more precise trials also identified significant soil x treatment interactions. Adjacent conventional small-plot trials gave LSDs between 0.34 to 1.8 t ha^{-1}.

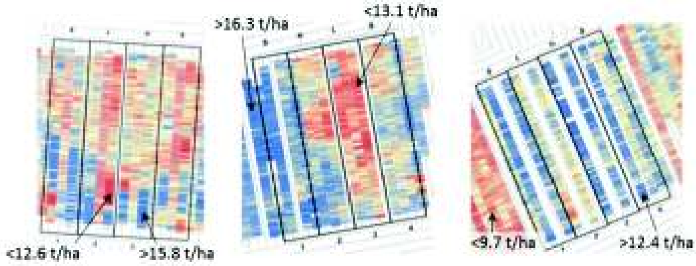

Figure 1. Three example yield maps from commercial harvesters showing effects of low (L), standard (S) and high (H) N treatments applied by farm spreader. Yields increase from red to blue.

Conclusions

Whilst the quality of data from yield monitors and statistical approaches could both be improved, and further validation is required, comparable precision can be achieved in tramline-scale comparisons as in small-plot trials. We conclude that wider adoption of an Agronōmics approach offers powerful opportunities for both farms and researchers to work jointly on questions that matter to both, at a scale that is relevant to commercial cropping, and that enables new understanding of soil (and other spatial) interactions.

Acknowledgements

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Reference

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