Understanding & managing in-field variability of rice growth & yield

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in a rice hull

- A new project commenced in the 2006–07 season to study the causes of variability in rice growth and yield across a field, and to identify management options to address the variability
- The project will conduct a series of field experiments to identify factors contributing to 'within field' yield variability
- The project will contribute to the maintenance of the NIR tissue testing service and assess the potential of using satellites to measure panicle initiation nitrogen uptake
- The project will use findings to develop the zone management aspect of the maNage rice package

Rice yields in southern NSW are high by international standards but within individual fields, yield is often highly variable. Advances in technology has seen the development of remote sensing and yield mapping which identify and measure 'within field' variability, however the factors that contribute to crop yield variability have not been identified.

To improve overall grain yield and profit, it is necessary to identify the factors which contribute to the within field variability observed in rice fields and then look at management approaches to alleviate the effects of these factors. Within field variability in rice growth and yield may be increased due to differences in soil salinity, soil sodicity, landforming cut and fill, and soil nutrient status.

Survey results using electromagnetic induction (EM) sensors, which respond primarily to variations in soil texture, salinity and moisture, have also been linked to other variable soil properties including sodicity, acidity and infiltration. Readily available sources of information identifying field variability, including EM maps, landforming cut and fill plans, yield maps and remotely sensed images of the field, are being used to investigate possible causes of rice yield variability.

This project, which commenced in the 2006–07 season, comprises three components:

1. field experiments related to identifying factors that contribute to within field yield variability
2. the maintenance of the NIR tissue testing service and assessing the potential of using satellites to measure PI nitrogen uptake
3. the zone management aspect of the maNage rice package.

The NIR rice nitrogen tissue testing service undertaken by SunRice and supported by NSW DPI research will be improved by the incorporation of new Bruker FT-NIR spectrophotometer with potential to improve analytical precision and speed of operation. The use of hyperspectral satellite imagery to provide NIR data on the spatial distribution of rice crop nitrogen content will continue to be explored.

The maNage rice package (version 6.0-6.2) contains a preliminary zone-management system by which users can divide a field into zones based on an image (such as an EM, NDVI or yield map) and then base their sampling strategy for nitrogen status at panicle initiation. This project will endeavour to improve how to identify the cut-off values for EM and the depth of cut and fill at which variable rate nitrogen management is economically justified.

Aims

The aims of the new project are as follows:

- identify factors that are contributing to within field yield variability
- develop approaches to alleviate the effect of these factors
- maintain NIR rice tissue testing capability
- further investigate hyperspectral imagery for NIR
- improve/increase capacity of maNage rice zone management.

Field experiments

In this project we are using EM maps and landforming cut and fill plans to identify field variability, allowing us to establish experimental sites across the variability in the field. Comprehensive measurement of many factors is undertaken at each site before and during the rice crop. Correlation between yield and all measured factors will be investigated in order to assess the factors contributing to yield variability.

In the 2006–07 season, four fields growing rice (two aerial sown and two drill sown) were investigated in detail. Each field was surveyed using EM sensors (EM31 and EM38). The digitised landforming map showing the spatial distribution and depth of cut and fill during land leveling was overlayed on the EM31 map, and sites covering the range of EM31 values and cut and fill were identified. Between 21 and 50 sites were selected in each field. EM31 and EM38 values were confirmed at each site.

At each site a 6 m x 6 m area was established which was soil sampled in the 0–10 and 10–20 cm depth intervals prior to rice growing. Two nitrogen rates, zero and a rate similar to that commercially applied to the field, were applied at each site. The nitrogen was incorporated prior to application of permanent water for the aerial sown crops and applied to dry soil prior to permanent water for the drill sown crops.

All inputs (ie water, herbicides and insecticides) were uniformly applied. Air and water temperatures were recorded in each field, and water depth, water salinity and weed growth were recorded at each site.

Plant measurements including establishment counts, dry matter and nitrogen uptake at panicle initiation and harvest, grain yield and yield components were also measured for both nitrogen rates at each site. Rice growth and yield measurements were correlated with EM values, cut and fill, and soil measurements.

Results

The mid-season reductions in water allocations in 2006 led to the partial abandonment of two experiments, reducing the number of sites and therefore the range of EM and cut and fill that were explored.

It can be seen from Figures 1 to 8 that there was considerable grain yield variability between sites in each field, and that in all fields the application of nitrogen dramatically increased yield above the zero nitrogen plots.

The effect of landforming cut and fill on grain yield was variable between fields. The most notable feature is that Field 2 (Figure 4) was topsoiled when landformed eight years ago and there was no effect of cut and fill on grain yield. The other three fields (Figures 2, 6 and 8) were not topsoiled and all show differences in grain yield related to cut and fill even though landforming occurred up to 15 years ago.

In the three fields that were not topsoiled, landforming appears to be the dominant effect on grain yield with the relationship between EM and grain yield in these fields being poor (Figures 1, 5 and 7). In the field that was topsoiled there is a significant relationship between EM31v values and grain yield, with increased EM31 values leading to reductions in grain yield (Figure 3).

Although there are general trends between EM or landforming cut and fill and grain yield, as would be expected, the EM and landforming plans are primarily being used to locate sites within the fields that cover the range of soil variability. The most important results, that will hopefully lead to recommendations to improve low yielding areas of the field, will come from correlations between plant establishment, growth and grain yield with soil, climatic and cultural factors. If, in the future recommendations are developed to improve the yield of lower yielding areas of the fields, then EM and landforming cut and fill maps will again become important, in identifying which areas in the field need to be managed differently.

NIR rice tissue test

The rice tissue testing service was conducted during 2006–07 using the existing NIRS 6500 instrument. The new Bruker FT-NIR instrument (Figure 9) purchased by SunRice was run in parallel with the existing NIRS 6500 instrument during 2006–07. The Bruker instrument has advantages in terms of possessing a carousel for automated scanning, sealed vials that reduce dust and contamination issues and allow for sample storage and re-scanning with minimal effort if necessary. An initial cross calibration between the instruments using the 2006–07 NIR tissue test samples is shown in Figure 10. Parallel instrument use will be undertaken in 2007–08 with rice crop nitrogen uptake recommendations being generated from the Bruker instrument.

Exploration of the utility of remotely sensed hyperspectral data will be pursued in the future as the opportunity for efficient data collection arises. Remote sensing of NIR by use of airborne HyMap sensors during 2006–07 was not undertaken due to the small area of rice cropping and the high cost of data collection. Additionally we were unable to access Hyperion data from the EO1 satellite controlled by NASA in the 2006–07 season.

maNage rice

Version 6.3 of maNage rice was released in November 2006 and is also available for downloading from the growers-only part of the SunRice website. Future versions of maNage rice will be available only on the website.

The main changes from version 6.2 are new sections on the effects of sowing date on yield, and electronic copies of a range of publications from DPI, RGA and SunRice in a Ricegrowers' toolkit. The largest additions are the weed images from 'Production of Quality Rice in South Eastern Australia'. The core of the maNage rice software is the model used to calculate optimum nitrogen fertiliser, TRYM (Temperate Rice Yield Model), which remains largely unchanged from previous versions.

The zone management screen in maNage rice is linked to TRYM so that the optimal rate of nitrogen fertiliser topdressing can be specified for different parts of a field. The first step is to identify the zones. To do so, an image of a field such as a yield map, aerial photo, satellite image, cut and fill map or EM (electromagnetic induction) map is imported into the software. Then it is necessary to provide two local reference locations such as eastings and northings,

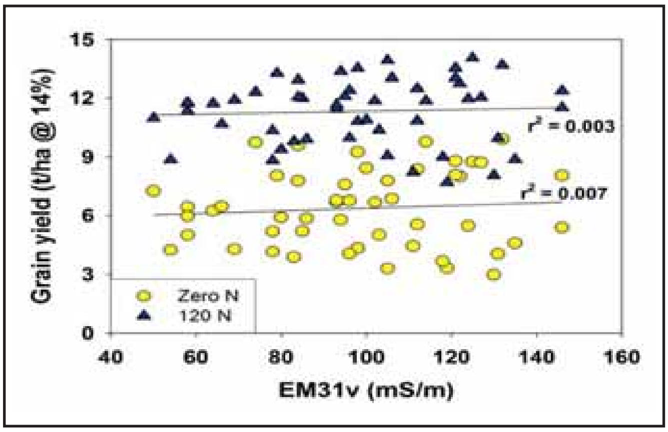

Figure 1. Field 1 EM31v and grain yield

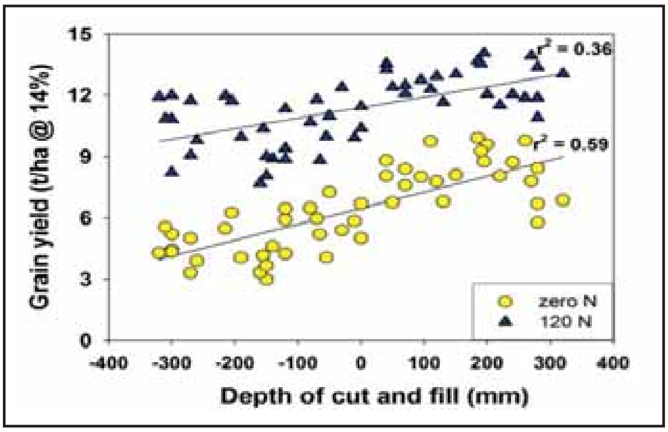

Figure 2. Field 1 Cut and fill and grain yield

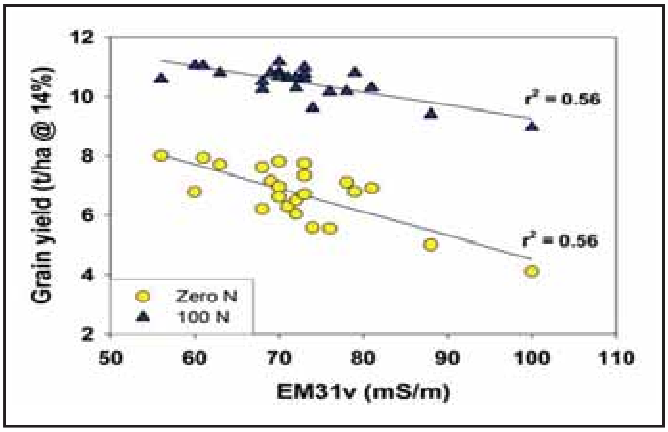

Figure 3. Field 2 EM31v and grain yield

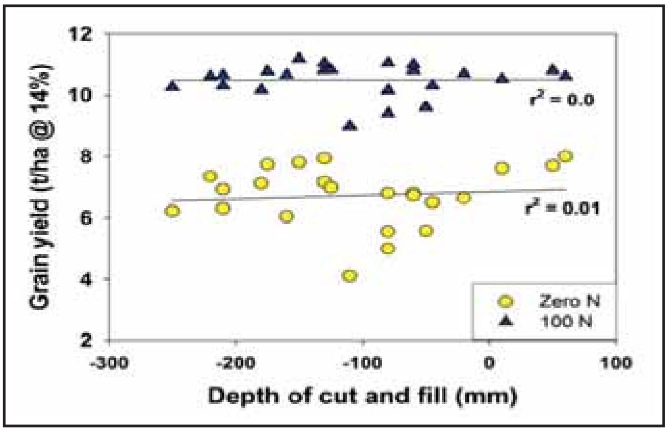

Figure 4. Field 2 Cut and fill and grain yield

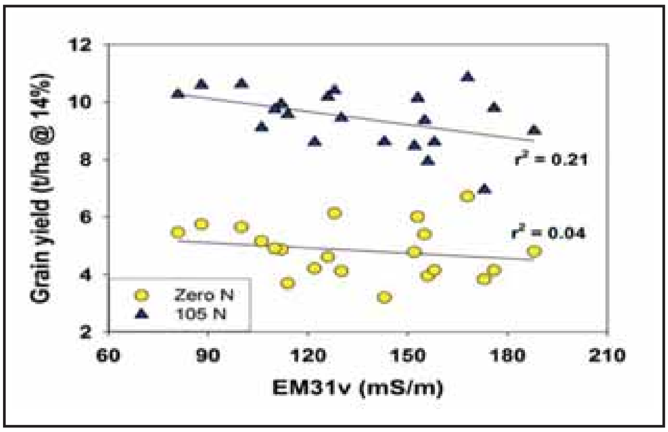

Figure 5. Field 3 EM31v and grain yield

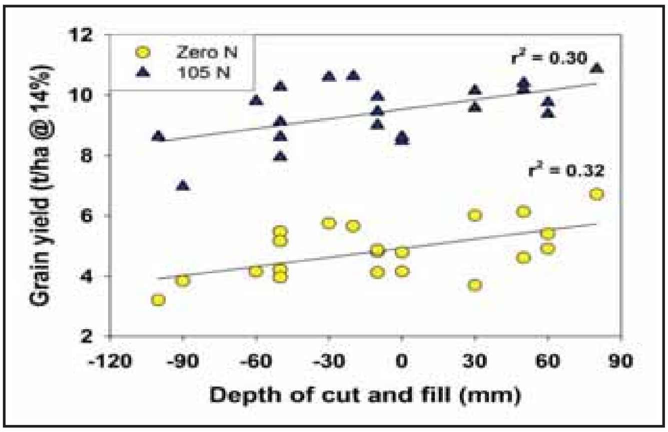

Figure 6. Field 3 Cut and fill and grain yield

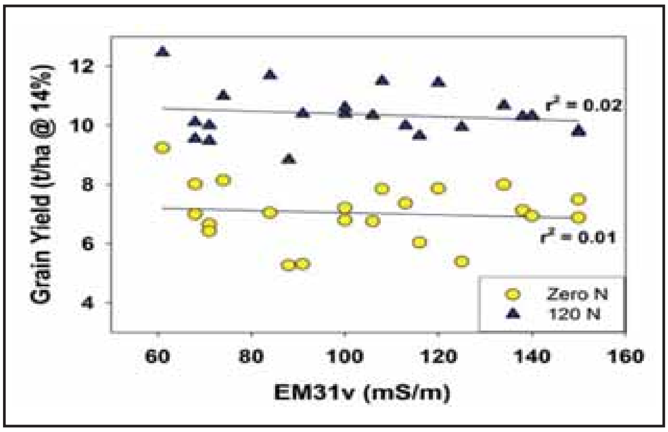

Figure 7. Field 4 EM31v and grain yield

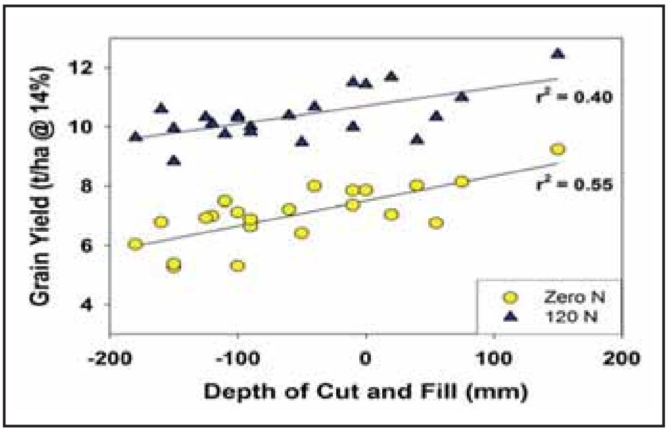

Figure 8. Field 4 Cut and fill and grain yield

for example from a GPS receiver or Google Earth. The accuracy of these positions need only be within about 10 m, since spread widths are at least this large.

Where the image shows different soil or crop conditions in the field it may be profitable to apply different rates of nitrogen. The distinct zones are drawn with the computer mouse as an overlay on the image. This places the user in control of defining the zones, using the image as a guide rather than the sole source of information. Plant samples for fresh weight and NIR tests can be collected and entered in the software to indicate optimum nitrogen for each zone. Local understanding is essential to interpret the results. For example zones that are low yielding because of a soil cut can generally benefit from more nitrogen fertiliser, but those that have a recent history of surface salt may not respond to nitrogen.

The software estimates the profitability of topdressing different zones in a field so it provides information to assist the decision on whether to topdresss the whole field uniformly, to topdress in zones or not topdress at all.

Our intention is to extend the capability of the maNage rice software to provide files for use in fertiliser controllers using shape files. This feature may provide an option for rice growers to communicate about fertiliser zones to consultants or contractors by emailing the shape files or writing onto a chip for use in their own machinery.

Conclusion

Preliminary results illustrate possible relationships between EM and cut and fill with grain yield. A comprehensive analysis of relationships between soil property and nutrient results and crop growth and yield will be carried out. Further experiments will be conducted to determine if the identified causes of variability are common among fields and if low yielding areas can be increased to levels at least similar to that of the current field average.

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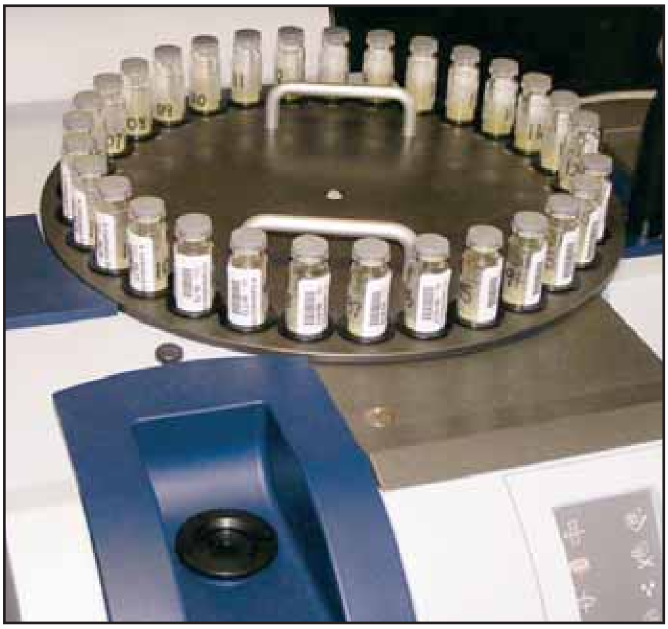

Figure 9. Bruker FT-NIR with 30 sample carousel

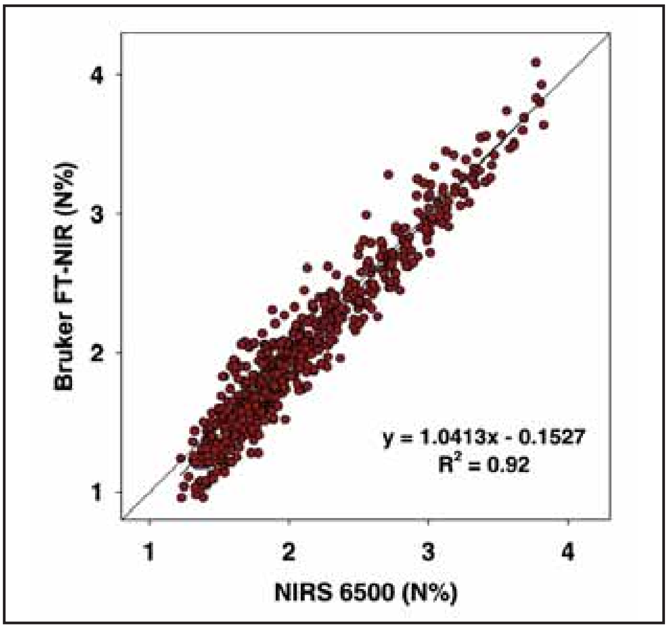

Figure 10. Preliminary relationship between NIRS 6500 and the new Bruker FT-NIR instruments.