



Remote sensing of nitrogen in rice crops

Sue Ciavarella¹, Laurie Lewin¹, Tony Blakeney² & Graeme Batten³

¹IREC, c/- NSW Department of Primary Industries, Yanco Agricultural Institute Yanco

²Cereal Solutions, North Ryde NSW, ³Sea Spec P/L, Woolgoolga NSW

IN A RICE HULL

- ▶ This project is investigating the potential to combine the precision of the NIR Rice Tissue Test with the sampling ease and overall "picture" provided by remote sensing imagery
- ▶ Current remote sensing produces a map distinguishing areas of differing vegetative growth, which can aid in determining where to take samples for NIR analysis but it is not a direct measurement of plant nutrients
- ▶ Correlations between spectral information from satellite imagery and results from traditional NIR tissue testing suggest a strong relationship between the two, paving the way for remote nitrogen testing for rice crops

This project is investigating the potential of combining the precision of the NIR Rice Tissue Test with the sampling ease of remote sensing.

Last year we reported that the current technology that produces aerial images of rice crops prior to panicle initiation (NDVI images or maps of normalised difference vegetation index) provide a good visual representation of differences in crop growth, but are a poor estimator of dry matter and a very poor estimator of nitrogen content of the crop canopy. The reason for this is based on the wavelength spectra used.

A typical visible-NIR spectrum of rice tissue is a series of crests and troughs extending across the visible region (400–700 nm) and NIR regions (700–2500 nm) of the electromagnetic spectrum. However the remotely sensed images currently available to rice growers use only two bands of the spectrum to distinguish areas in the crop with different vegetative growth. The NDVI is established using bands are between 660 and 680 nm and 780 and 840 nm. These bands are not near the nitrogen absorption bands, which are located in the regions between 1250 and 1600 nm and between 2000 and 2300 nm. It is for this reason that NDVI is a poor estimator of dry matter and a very poor estimator of canopy nitrogen content.

The project has begun testing the whole NIR spectrum to see if good correlations between field data and NIR results from the laboratory can be obtained. Last year, using a hand-held radiometer we were able to obtain spectral information of rice in a standing crop and compare it with the spectral information of dried and ground rice tissue obtained on the laboratory NIR instrument. Correlations in the areas rich in "nitrogen information" were as high as 0.99, suggesting a strong relationship between the results from the two

measurement techniques.

What's new from 2005?

In 2005 we compared the information from satellite imagery with that from NIR analysis of tissue taken from the same positions in standing rice crops.

The imagery from the Hyperion and ALI sensors on board the Earth Observation-1 (EO-1) satellite was made available through CSIRO Canberra. The Hyperion sensor on board the satellite is the first hyperspectral sensor on an earth observation satellite and it records light reflected from the earth (spectral reflectance data), across the wavelength range 400 to 2500 nm in 220 bands. The EO-1 satellite orbits 705 km above the earth's surface from north to south. Travelling at 7.5 km/sec, each orbit takes nearly 99 minutes.

Thus the spacecraft completes just over 14 orbits per day

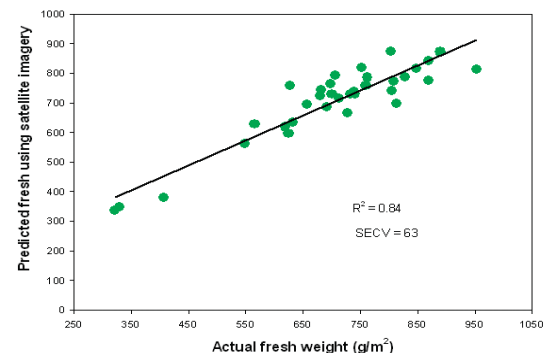


Figure 1 Preliminary prediction of fresh weight (g/m^2) in standing rice crops using satellite imagery (400–2500 nm)



and covers the entire earth every 16 days. The Hyperion sensor on board the spacecraft obtains data along the ground track at a fixed swath width of 7 km. It can be tilted sideways to centre on specified points and the minimum recorded area (pixel) is a 30 x 30 m square.

We imported the spectral reflectance data into the software used in the benchtop NIR instrument, here at Yanco. The satellite data was calibrated with the fresh weight, nitrogen content (%N) and nitrogen uptake values derived by field sampling and NIR analysis of 38 samples taken at specific points related to the satellite's recording points. Some really exciting figures emerged! (see Table 1 and Figures 1–3).

Table 1 shows good correlation between the reflectance data from the satellite and each of the crop factors measured at ground level, ie dry weight of the crop, nitrogen content and nitrogen uptake. Good correlation means that the results from satellite imagery are quite reliable for predicting crop factors that are obtained in the labour intensive process of panicle initiation crop sampling.

The strength of the correlation is represented by an R^2 value (third column of Table 1). The higher the R^2 , the stronger the relationship. The values obtained in this investigation, 0.84–0.89, mean that 84–89% of the time the satellite data will accurately predict the crop factor.

To further test the relationship, a standard error of cross validation (SECV) was calculated (last column of Table 1). The value obtained indicates how well the NIR results relate to a standard analysis. If the SECV is zero and the R^2 is 1, then there would be a perfect relationship – this however is unlikely to occur in the real world.

On the basis of our experience of NIR calibrations, these SECV results mean that the samples can be divided reliably


into at least 4 categories for dry weight, 3 categories for % nitrogen and 5 categories for nitrogen uptake. The categories would represent levels of results that could be interpreted as high, medium or low (as well as intermediate levels for dry weight and nitrogen uptake).

These results have been obtained using only 38 samples over a restricted range of values. With additional data gained over a number of years, it is hoped that stronger relationships between imported reflectance data and crop factors will be established.

Future work

We need to continue this work for several years to develop robust calibrations and work out the best way to utilise this technology in rice crop management.

It should be noted that the calibrations initially obtained for the current NIR Rice Tissue Test improved steadily from 1987 and that the calibrations obtained from the satellite data preliminary study are not much worse than those we began with in 1987.

Ultimately, the establishment of strong relationships between reflectance data obtained from satellites and data obtained from field samples at panicle initiation, could mean that panicle initiation sampling becomes a thing of the past and all the information required to learn about crop nitrogen requirements to determine panicle initiation nitrogen applications could be obtained by remote sensing. 

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Sue Ciavarella

Professional Officer, Yanco Agricultural Institute

T: 02 6951 2611

E: susan.ciavarella@dpi.nsw.gov.au

Table 1

Correlation statistics between the imported reflectance data from the satellite 705 km above the earth's surface, and data obtained from field sampling and NIR analysis.

Constituent	Range	R^2	Standard error of cross validation
Dry weight (kg / ha)	322–953	0.84	63
Nitrogen (% N)	1.11–2.25	0.88	0.16
Nitrogen uptake (kg N/ha)	67–190	0.89	13

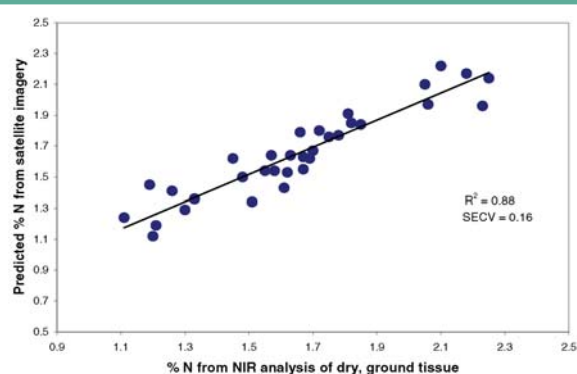


Figure 2 Preliminary prediction of nitrogen content (%N) in standing rice crop using satellite imagery (400–2500 nm)

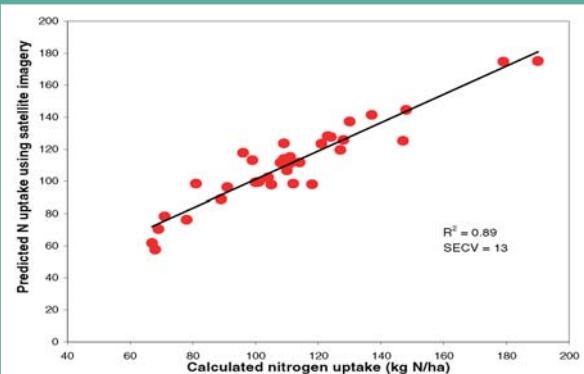


Figure 3 Preliminary predictions of nitrogen uptake (kg N/ha) by standing rice crops using satellite imagery (400–2500 nm)