Using remote sensing to predict PI nitrogen uptake in rice

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Key findings

- Remote sensing can confidently be used to map a rice crop's panicle initiation (PI) nitrogen (N) uptake.
- A remotely sensed image of nitrogen uptake at PI can identify variability in the uptake and enable variable rate nitrogen topdressing to maximise grain yield with reduced risk.
- Remotely sensed data has been collected using field spectroradiometer (SVC HR1024), multispectral cameras including the MicaSense RedEdge, Tetracam MCA and Headwall Hyperspectral Imager, and Worldview 3 satellite data.

Introduction

Applying nitrogen to a rice crop at panicle initiation to increase yield is efficient and reliable. The NIR (Near Infra-red Reflectance) tissue test has been the industry standard for measuring crop growth and nitrogen at panicle initiation since the mid 1980s. However, many growers and agronomists do not take advantage of this technology and instead rely on estimating the rice crop's nitrogen requirements. One of the main reasons growers do not use the test is difficulty in sampling the rice crop in the water.

Researchers have been investigating using remote sensing to predict PI nitrogen uptake with very encouraging results. Remote sensing derived PIN (panicle initiation nitrogen) uptake maps would reduce the need to physically sample the crop and would also provide a greater understanding of within-crop spatial variability. Four years of research have been conducted to determine if rice PIN uptake can be predicted using remote sensing from drones, aircraft and satellites as part of an ongoing Rural Industries Research & Development Corporation (RIRDC) research project.

Method

Each year a series of experiments were set up using several commercial rice varieties. Across the varieties, a range of nitrogen rates were applied to create plots with a large range in PIN uptake levels. These plots were measured at PI using several remote sensing instruments, physical samples were also collected. The relationship between the remotely sensed data and the physically measured rice crop PIN uptake were investigated. Over the four years of the project, 885 plots were imaged and PIN uptake physically measured.

In the first three years of the project, plots were measured with a field portable hyperspectral radiometer (SVC 1024) mounted on a four-wheel motor bike (Figure 1). This instrument uses the same wavelengths (400–2400 nm) as the laboratory NIR instrument, which is very accurate at determining rice tissue nitrogen content at PI. We were then able to determine how accurately PIN uptake could be measured using the best possible instrument and conditions, and also determine the optimal wavelengths to achieve the greatest correlation with PIN uptake. This information has provided confidence that remote sensing can determine rice PIN uptake (Figure 2).

Figure 1. Collecting rice canopy spectra using a hyperspectral scanner mounted on a four-wheel motor bike.

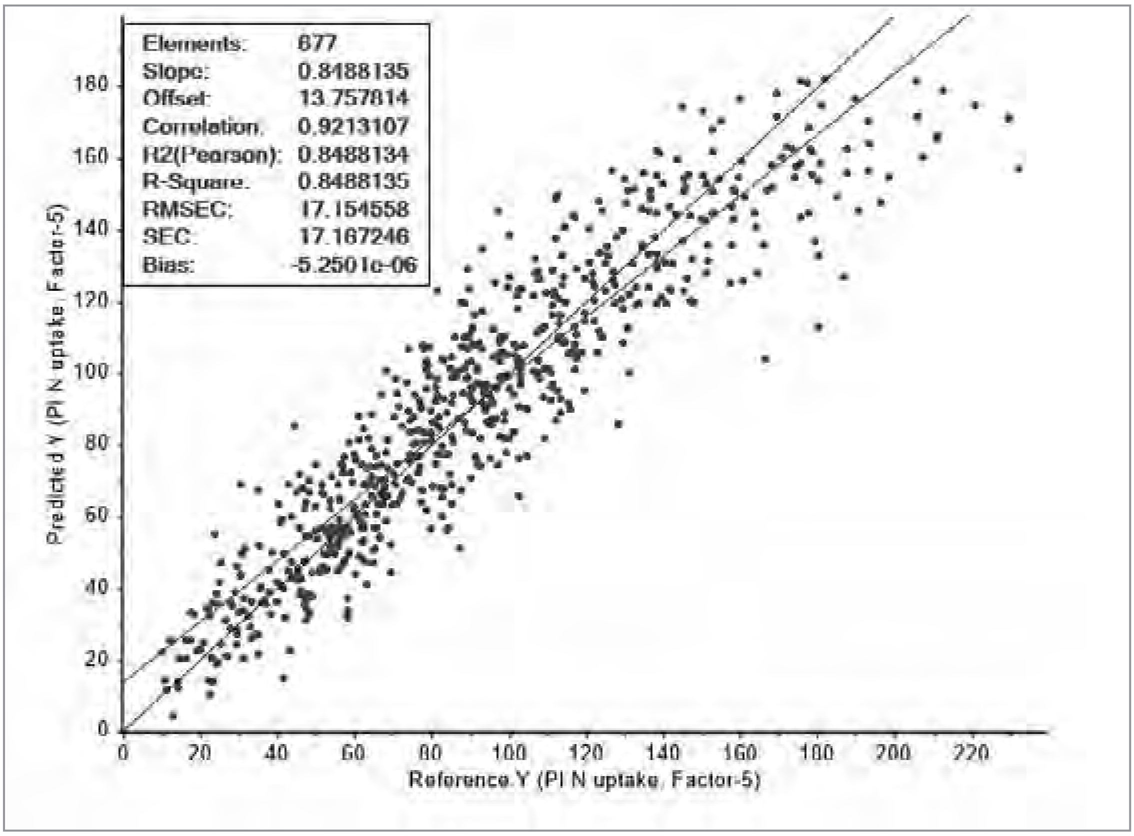

Figure 2. Measured vs predicted PIN uptake (kg N/ha) from 677 plots scanned over three seasons with a hyperspectral scanner mounted on a four-wheel motor bike.

Data from a minimum of 100 plots (including two seasons and several rice varieties) are required before a realistic evaluation of each instrument is possible. Multi-season correlations have been developed between the data and measured crop PIN uptake for several multispectral and hyperspectral systems (Table 1).

Results

All instruments can create a normalised difference vegetation index (NDVI) from the canopy reflectance measured and produced similar correlations between NDVI and PIN uptake. At low PIN uptake levels (below 100 kg N/ha) NDVI showed a reasonable relationship with PIN uptake. At higher levels (above 100 kg N/ha) the relationship between NDVI and plant nitrogen uptake plateaued, with the NDVI unable to detect, and therefore predict, changes in PIN uptake.

Alternatively, very high resolution satellite imagery might prove to be an accurate and affordable option. The first season of the Worldview 3 satellite data has shown considerable potential and when the second season's data (current season) is analysed, a better understanding of its potential can be determined. A satellite-based remote sensing system with automated processing and delivery systems that could generate near real-time management decisions to industry and growers could be an option.

Table 1.The range of instruments used to collect remotely sensed data from the rice variety and nitrogen experiments.

Remote sensing instrument	Collection method	Bands	Data collected
SVC 1024	Ground	Hyperspectral (330–2500 nm)	3 seasons
Greenseeker	Ground	NDVI	2 seasons
Aerial NDVI	Aerial	6 bands (490–900 nm)	3 seasons
micaSense	Aerial	4 bands with red edge	1 season
HyVista Hymap	Aerial	Hyperspectral (430–2450 nm)	1 season
Worldview 3	Satellite	8 bands (400–1040 nm)	2 seasons

The three years of hyperspectral and multispectral data have identified the wavelengths that best predict PIN uptake. This provides an opportunity to develop a relatively inexpensive camera with filters to measure those wavelengths that predict PIN uptake. This camera could be mounted in an aircraft to measure rice fields across the industry. This option has the added benefit of making data collection timing more flexible, thus reducing the risk of clouds interrupting the process.

Summary

Data analysis from the current season will enable identification of sensing technology that predicts PIN uptake most accurately and affordably. The project team will then start to develop a semi-commercial system for determining rice PIN uptake. It is expected that this will be trialled in the 2016–17 rice season. It might be a few years before growers can obtain a PIN uptake map of their rice fields using this method, but it appears to be a reality in the near future.

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