Estimating the uptake of nitrogen by rice crops using near infrared reflectance analysis of soil

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Introduction

Rice growing in south-eastern Australia has a high dependence on nitrogen fertiliser. Yields have been limited due to insufficient nitrogen being applied pre-flood. The risks associated with applying high rates of pre-flood nitrogen include increased susceptibility of high N status crops to cold induced sterility and lodging.

The barrier to adoption of higher rates of pre-flood nitrogen is the lack of a suitable pre-rice soil nitrogen test. Many farmers prefer to use a conservative pre-flood rate and top-dress at panicle initiation (PI) after a near infrared (NIR) based nitrogen tissue test.[1] However, greater efficiency in fertiliser usage could be obtained if a reliable soil N test was available.

NIR has been shown to be useful in determining soil moisture, organic carbon and nitrogen[2] and is used routinely to test soil by a fertiliser advisory service.[3] This study investigates the ability of NIR to estimate the soils N supply potential to a rice crop.

Materials and methods

Soil samples were collected from two rice-based experiments conducted at the Yanco Agricultural Institute in south-east Australia. Both experiments were located on a red–brown earth, which is typical of many soils used for rice growing in this region. In both experiments the soil samples and plant measurements were taken when a final comparative rice crop was grown over all treatments.

The samples were air-dried then ground in a centrifical grinder with a 2 mm sieve, to give a very fine particle size. 70 g sub-samples of soil were placed in 125 × 225 mm × 60 mm clip top plastic bags (Figure 1). The bag containing the ground soil was folded to present a clear face when loaded in a coarse grain cell with a 12 mm thick piece of foam placed behind the sample to hold it firm against the glass of the NIR cell.

Figure 1. The coarse grain cell, soil sample in bag and 12 mm thick foam.

Figure 2. NIRSystems 6500 spectrophotometer.

An NIRSystems model 6500 scanning spectrophotometer (Figure 2) was used to obtain soil spectra at 2 nm intervals between 1100 and 2500 nm wavelengths over 3/4 the length of the cell. Each spectra was the average of 100 scans of the soil.

The NIR spectra of each soil sample from each experiment was calibrated against the incubation ammonium content of the soil, nitrogen uptake at PI and grain yield of the following rice crop. In all calibrations, the spectra were transformed by 2nd derivative mathematical formula, then multiple linear regressions were used to identify four wavelengths using NSAS software.

Results

Figures 3 and 4 illustrate the range of values for each constituent measured in Experiments 1 and 2, respectively. The calibration results for NH_4 incubation were similar for both experiments.

For the plant measured constituents, soils from Experiment 2 gave much lower standard errors and higher R^2 values for both the calibration and validation sets (Table 1). In Experiment 1, soil was sampled prior to three "flush" irrigations, while in Experiment 2, soil sampling occurred after the three flush irrigations which cause considerable N transformations and losses prior to permanent flood. The best calibration was achieved for PI N uptake in Experiment 2, which was soil sampled immediately prior to permanent flood.

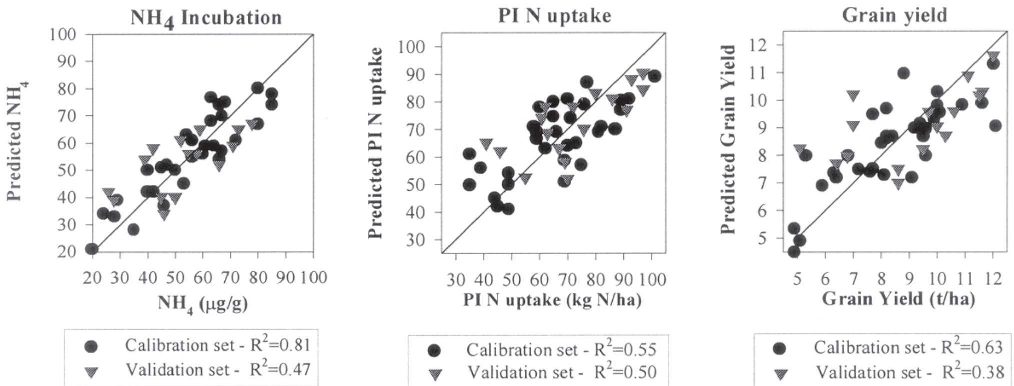

Figure 3. Calibration and validation results from Experiment 1.

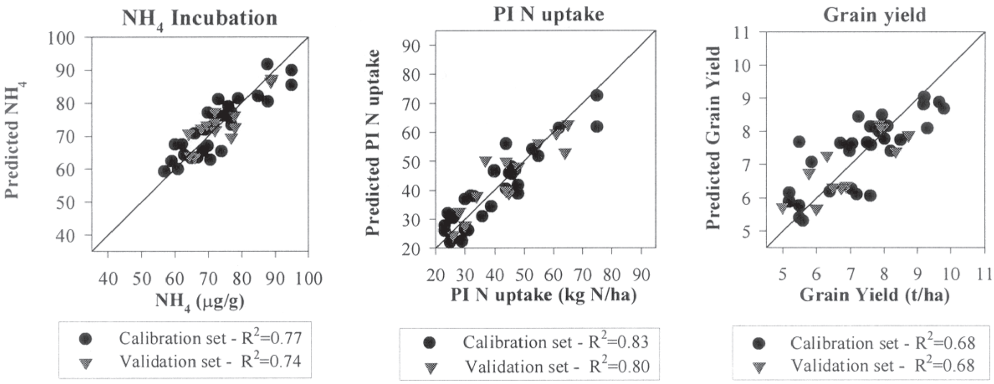

Figure 4. Calibration and validation results from Experiment 2.

Conclusions

The results from the soil NIR calibrations developed here suggest that an NIR soil test for PI N uptake in rice may be beneficial for managing N fertiliser applications to achieve high economic yields.

Calibrating a soil N-test to PI N uptake is more effective than calibrating against grain yield, due to the larger numbers of variables which affect grain yield. There is a strong relationship between PI N uptake and rice grain yield.

An NIR-based test could provide soil N data within five days of sampling which is considerably sooner than the 14–20 days needed for the inaccurate incubation N test it would replace.

The results appear encouraging, but were achieved from a relatively small number of samples on the same soil type. Further research is being undertaken in the CRC for Sustainable Rice Production using over 100 sites, covering all rice growing areas and soil types with the aim to develop a commercial soil nitrogen test.

Table 1. Calibration and validation results from Experiments 1 and 2.

	Calibration				Verification		
	Range	N	*SEC*	R^2	N	*SEP*	R^2
Incubation NH^4 Experiment 1	20–85	31	8.26	0.81	16	11.3	0.47
Experiment 2	56–95	29	5.24	0.77	13	4.18	0.74
PI N uptake Experiment 1	35–107	33	12.9	0.55	17	11.9	0.50
Experiment 2	24–75	29	6.35	0.83	13	6.06	0.80
Grain Yield Experiment 1	4.9–12.1	33	1.29	0.63	16	1.67	0.38
Experiment 2	5.2–9.6	30	0.83	0.68	12	0.66	0.68

References

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