Precision Ag Trials

Riverine Plains 2010 crop reflectance and nitrogen requirement trials

Dookie, Vic

Although PA tools have been available to Australian grain growers for many years, and the benefits have been well documented, it is estimated that less than 1-% of grain growers utilise PA ‘beyond guidance’ in any form.

The objective of this GRDC / SPAA funded project is to increase the level of adoption of PA ‘beyond guidance’ by broadacre farmers. The project specifically aims to increase the level of adoption of variable rate (VR) by growers in the project to 30% by 2013. This goal will be achieved by demonstrating how to use PA tools to growers at a regional level and by increasing the skills of growers and industry in PA to a level where they can then use PA tools in their farming systems to achieve economic, environmental and social benefits.

Trials and demonstrations are conducted on growers’ properties and are visited throughout the season using farm walks and workshops to discuss the advantages and disadvantages of PA techniques with the involvement of other regional growers.

This information sheet presents the outcomes of the Riverine Plains crop reflectance and nitrogen requirement trials from season 2010.

Aims:

- To demonstrate the use of crop sensors.
- To explore the relationship between in-season crop reflectance, crop biomass and crop nitrogen content.
- To assess the suitability of the data to assist in making decisions on crop nitrogen requirements.

Background:

This trial is important to help farmers understand the use of crop sensors and to be able to use the data to assist in making decisions on crop nitrogen requirements.

About the trial:

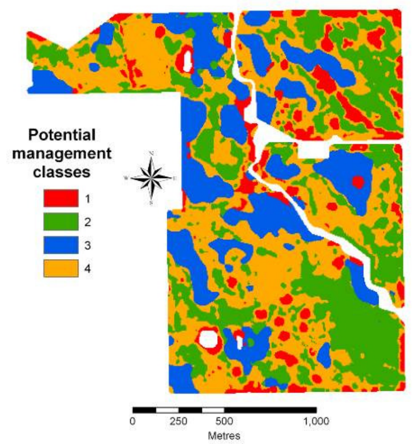
During 2010, trials were carried out on a number of paddocks near Dookie, Vic and Yarrawonga, Vic to explore the relationship between in-season crop reflectance, crop biomass and crop nitrogen content. In-season crop reflectance was measured using CropCircle sensors, which use NDVI (Normalised Difference Vegetation Index).

The ultimate goal is to assess the suitability of the data to assist in making decisions on crop nitrogen requirements as the season unfolds. In this report, one of the paddocks at Dookie is used as an example.

Results:

Nitrogen prescription based on historical information and deep soil nitrogen tests

Following promising results during 2009, the trial was expanded to include an extra two paddocks and a variable rate nitrogen program. The paddocks were originally divided into four potential management classes based on soil electrical conductivity (ECa), elevation and historical yield (see Figure 1a).



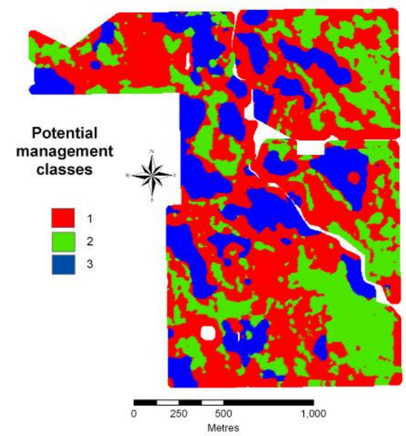


FIGURE 1 Four management classes (a) and the condensed three management classes (b)

Table 1 Class attributes and pre-sowing available nitrogen data for the three-class map (see Figure 1b)

Class	Soil EC_a	Yield	Elevation	Available nitrogen (kg N/ha)	Yield goal (t/ha)	Required crop nitrogen uptake (kg N/ha)	Available nitrogen shortfall (kg N/ha)
1	low	Low	high	115	4.5	95	75
2	med	High	high	152	5.0	105	58
3	high	Med	low	144	5.0	105	66

Class 1 only covered 9% of the area and included the tops of sandy ridges and areas with trees. From an input management perspective it was deemed that combining Class 1 with the similar and much larger surrounding Class 4 would simplify operations, while maintaining a large enough separation between the final three classes, as shown in red in Figure 1b.

Class 2 covered the area expected to be the highest yielding. Class 3 covered the lower-lying areas of the paddock, which were expected to be medium yielding. Soil sampling for available nitrogen across the classes provided average class results (see Table 1). The higher-yielding Class 2 had more available nitrogen than the lower-yielding Class 1.

Yield targets were set at 4.5t/ha for Class 1 and 5.0t/ha for Classes 2 and 3. Crop nitrogen uptake required for these target yields (and 12% protein content) can be calculated as:

$$\mathbf{4500}_{(kg/ha)} \times 0.12 \times 0.175 = \mathbf{95}_{(kgN/ha)}$$
$$\mathbf{5000}_{(kg/ha)} \times 0.12 \times 0.175 = \mathbf{105}_{(kgN/ha}$$

Assuming a 50% nitrogen uptake efficiency, the shortfall in the soil at the time of sampling was calculated and is shown in Table 1. These figures were used to calculate an initial nitrogen prescription where more nitrogen was to be applied in the low-nitrogen Class 1, with the rates reducing for Class 2 and Class 3.

A prescription map was built from Figure 1b whereby the management zone boundaries were simplified and small unmanageable patches were absorbed into the majority class for a zone. Small strip rate trials were also included (see Figure 2a). The 'as applied' map from 8 July 2010 is shown in Figure 2b.

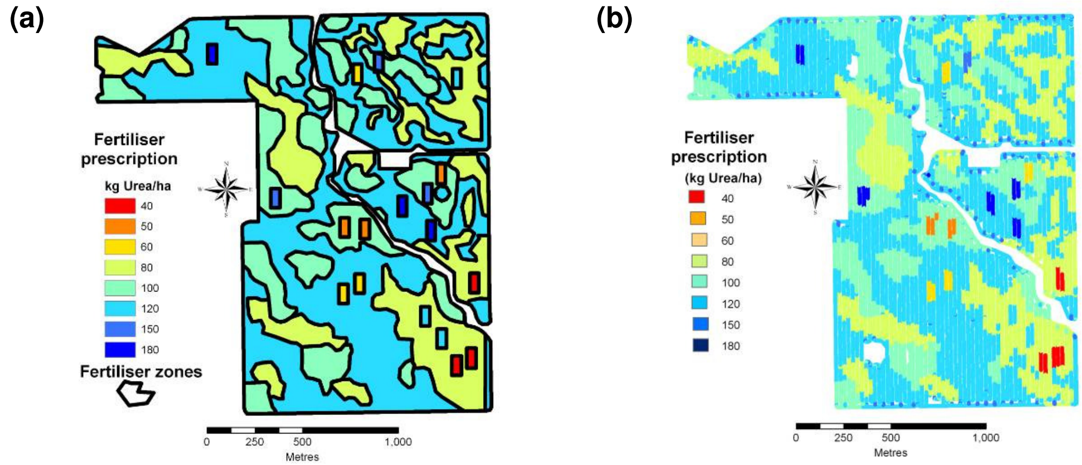


FIGURE 2 The initial nitrogen prescription map (a) and the 'as applied' variable-rate application map from 8 July 2010(b)

The variable rate application of urea for paddock B1, took place on 8 July 2010, and is shown in more detail in Figure 3.

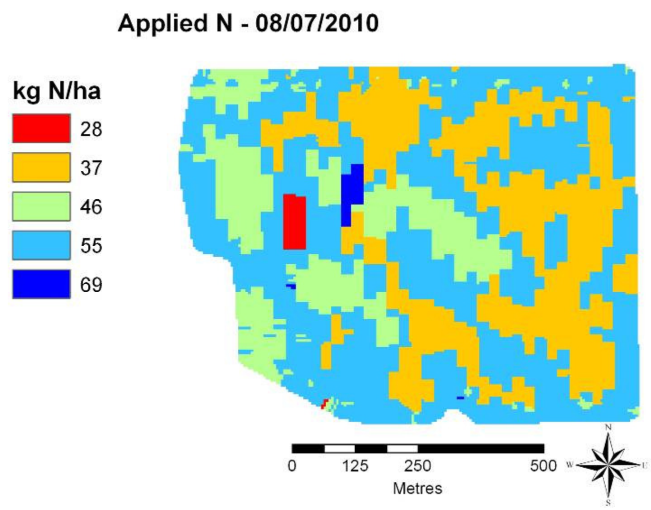


FIGURE 3 First nitrogen application based on three different levels and including small strip trials

Reflectance measurement

Four CropCircle reflectance sensors were spread equally across a 25m boom and driven on a 25m swath survey within the paddock on 7 August 2010 (see Figure 4). The correlation between the reflectance during 2010 and 2009 was high (r=0.8), which suggests the data is strongly influenced by the interaction of local factors.

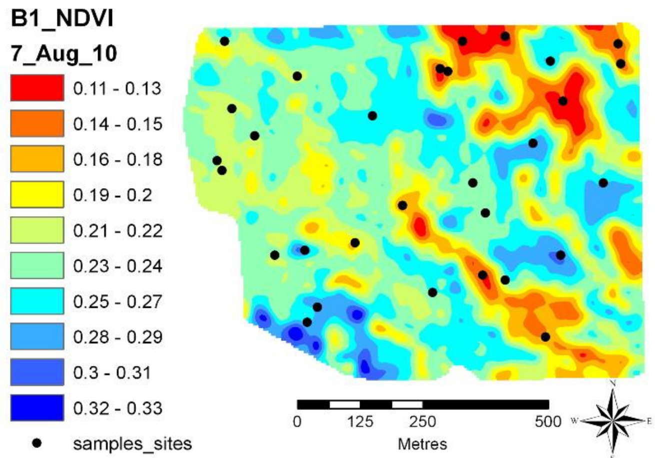


FIGURE 4 Crop reflectance data (NDVI) for the wheat crop on 7 August 2010 plus crop sampling sites

Crop samples were to be taken from the same sites as 2009 to measure crop nitrogen percentage, dry matter (DM t/ha) and shoots (m2). Total nitrogen in the crop (kg/ha) can be calculated by:

$$\mathbf{TotalN}_{(kg/ha)} = \frac{\mathbf{N\%}}{\mathbf{100}} \mathbf{\ x\ (DM}_{(t/ha)} \mathbf{\ x\ 1000)}$$

The season became quite wet following the reflectance survey, and access for sampling became impossible.

Sampling was delayed, but the high correlation between the NDVI maps from 2009 and 2010, meant the calibration made from the 2009 sampling data could be applied to the 2010 reflectance data (see Figure 5).

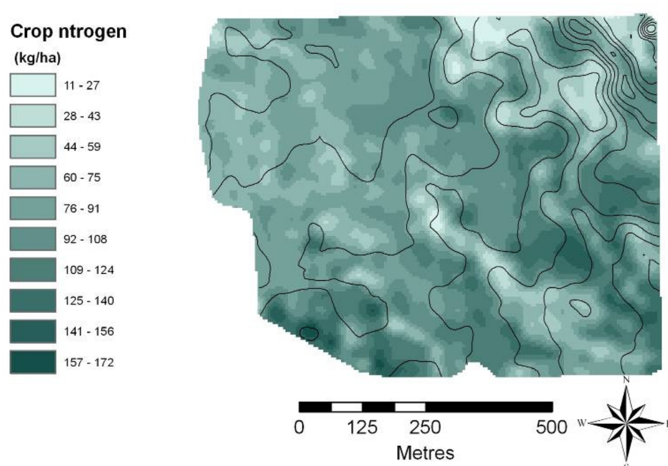


FIGURE 5 Total nitrogen uptake in the crop predicted from 2010 NDVI and the 2009 calibration

This map predicted that some areas in the paddock had already taken up the required nitrogen to reach the 5.0t/ha yield target, but in Class 1 nitrogen levels remained low. The full soil moisture profile, the expectation for a productive season and the information shown in Figure 5 all supported the undertaking of a second variable rate urea application on 23 August 2010. The application map is shown in Figure 6a.

Continuing wet weather delayed crop sampling but encouraged a blanket application of an additional 46kg/ha of nitrogen to maximise yield and encourage higher grain protein content. The map of total nitrogen applied to the paddock is shown in Figure 6b.

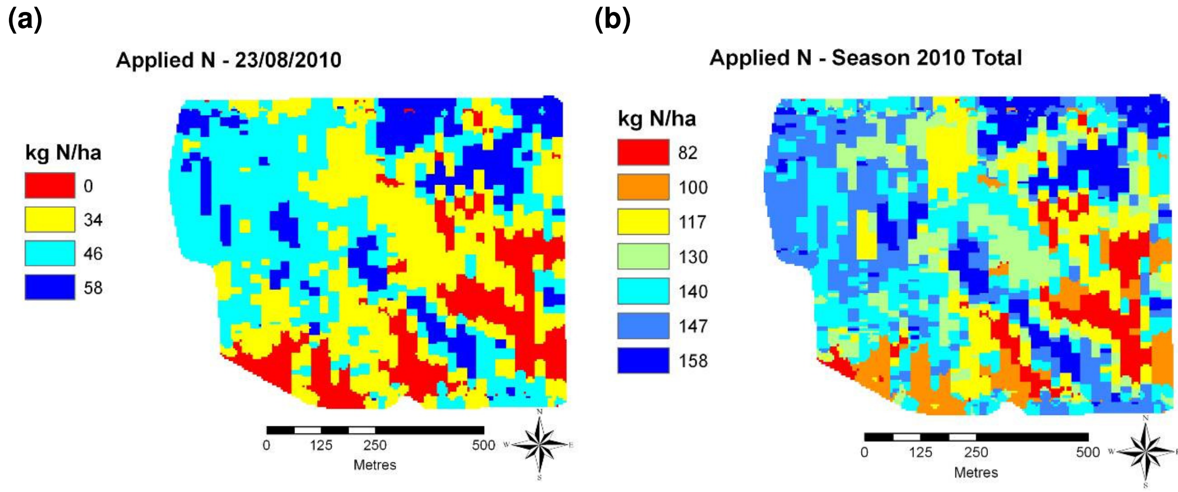


FIGURE 6 The second nitrogen application based on the 2010 reflectance data and the 2009 total nitrogen calibration (a) the total amount of nitrogen applied to the paddock (b)

Crop sampling

Crop sampling finally took place on 20 October, 2010 with the crop at mid milk stage (GS75).

Table 2 shows the relationships between the measured crop attributes and the NDVI. These relationships were generally stronger than during 2009. NDVI has a strong positive relationship with shoots/m2 (r=0.74) and DM (r=0.91), however it demonstrates a poorer relationship with nitrogen percentage (N%) (r=0.22). A strong positive relationship with total nitrogen (r=0.85) can be seen due to the incorporation of the DM figure in the calculation.

TABLE 2 Relationships between the measured crop attributes at the sampling sites

	NDVI	Nitrogen %	DM	Shoots / m2	Total N kg/ha	Soil ECa	Elevation	Yield
NDVI	1.00	0.22	0.91	0.74	0.85	-0.02	-0.30	0.82
nitrogen %	0.22	1.00	0.24	0.41	0.58	-0.12	-0.13	0.12
DM	0.91	0.24	1.00	0.83	0.92	-0.17	-0.01	0.86
Shoots /m2	0.74	0.41	0.83	1.00	0.86	0.33	-0.34	0.66
Total N	0.85	0.58	0.92	0.86	1.00	-0.21	-0.02	0.74
Soil ECa	0.16	-0.13	0.05	-0.26	-0.02	1.00	-0.56	0.14
Elevation	-0.39	-0.05	-0.34	-0.16	-0.29	-0.56	1.00	-0.49
Yield	0.82	0.12	0.86	0.66	0.74	0.14	-0.49	1

Correlation coefficient interpretation: 1 = perfect positive correlation - as the value of one attribute rises, so does the other by the same relative amount; -1 = perfect negative correlation – as the value of one attribute rises, the other falls by the same relative amount. For N = 30 samples: values greater than +/- 0.36 significant at p = 0.05. Values greater than +/- 0.46 significant at p = 0.01.

Given the purpose of the sensors is to help manage nitrogen application, the prediction of total crop nitrogen from the reflectance data is a main goal. The prediction can be improved by combining some basic information that should be available to most precision agriculture (PA) growers (elevation and soil ECa) with the NDVI data. In this paddock, the inclusion of elevation significantly improved the predictive ability from an R2 value of 0.71 to 0.74 (see Figure 7a). This calibration was applied to the NDVI map to produce the map of total crop nitrogen (see Figure 7b).

While this map was made using NDVI and crop sample data taken eight weeks apart, the calibration is quite strong. As was shown during 2009, when two NDVI surveys were taken three weeks apart, the pattern has been stable in this paddock.

The data shows the NDVI taken just prior to first node stage (GS30) can be used to predict the pattern and amount of nitrogen uptake at GS75. This is a significant finding for the practical use of these tools in nitrogen management. Figure 7b shows the crop across the entire paddock is predicted to have taken up enough nitrogen to achieve yields above the initial targets.

Efficiency of converting crop nitrogen to final grain yield

Figure 8a shows the conversion rate of crop nitrogen into crop yield decreases as the total amount of nitrogen in the crop increases. So the more nitrogen taken up by the crop, the less efficient the plant is at using nitrogen to photosynthesise and produce grain. Figure 8b shows that while this is occurring, the crop yield of the plant still rises with increased nitrogen up to about 250kg/ha. Past this level there appears to be an absolute waste of nitrogen.

During 2009, where there was a lower amount of moisture available for crop growth, the total nitrogen in the crop at sampling was less than during the 2010 season. This was also the case for yields. The combination of the data from the reflectance data is a main goal. The prediction can be improved by combining some basic information that should be available to most precision agriculture (PA) growers (elevation and soil ECa) with the NDVI data. In this paddock, the inclusion of elevation significantly improved the predictive ability from an R2 value of 0.71 to 0.74 (see Figure 7a). This calibration was applied to the NDVI map to produce the map of total crop nitrogen (see Figure 7b).

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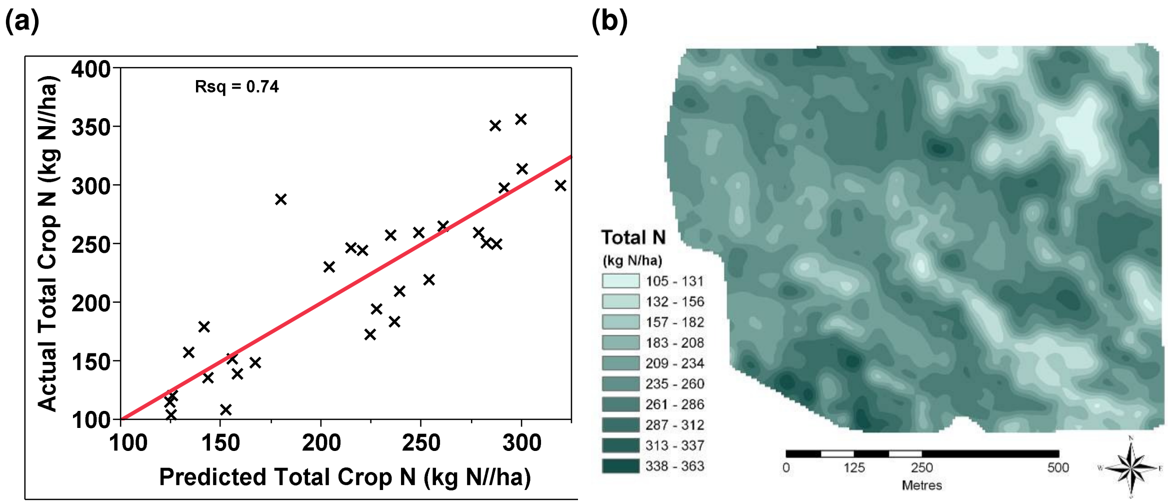

FIGURE 7 Calibration of crop nitrogen predicted by the NDVI and the actual crop nitrogen (a) and the result of applying this calibration to the whole paddock NDVI data (b)

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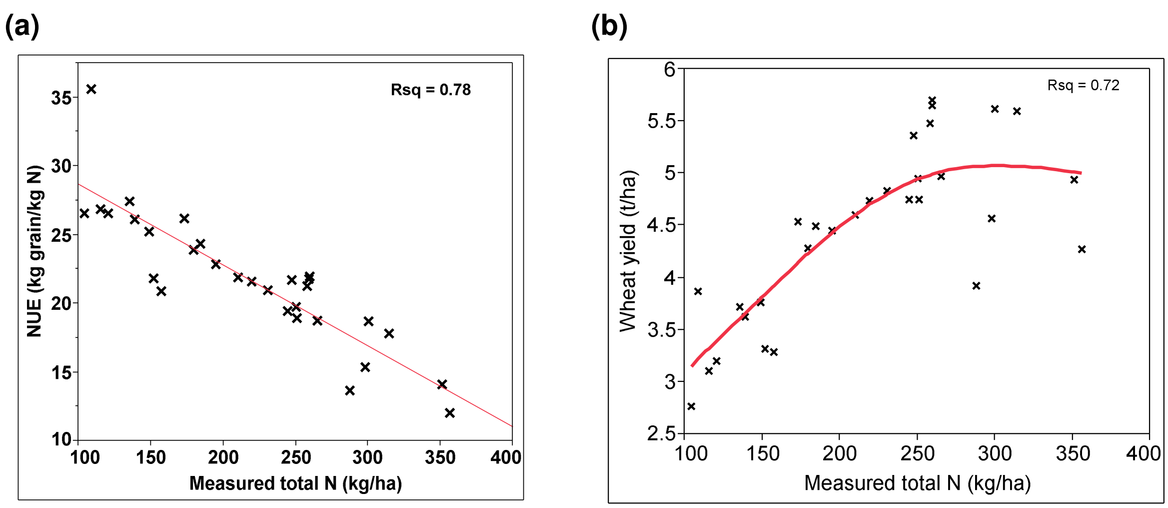

FIGURE 8 The efficiency with which crop nitrogen is converted to grain (a) and the absolute yield

During 2009, where there was a lower amount of moisture available for crop growth, the total nitrogen in the crop at sampling was less than during the 2010 season. This was also the case for yields. The combination of the data from the two seasons is shown in Figure 9. The data was gathered from an eight-week window of observation from GS30 to GS75.

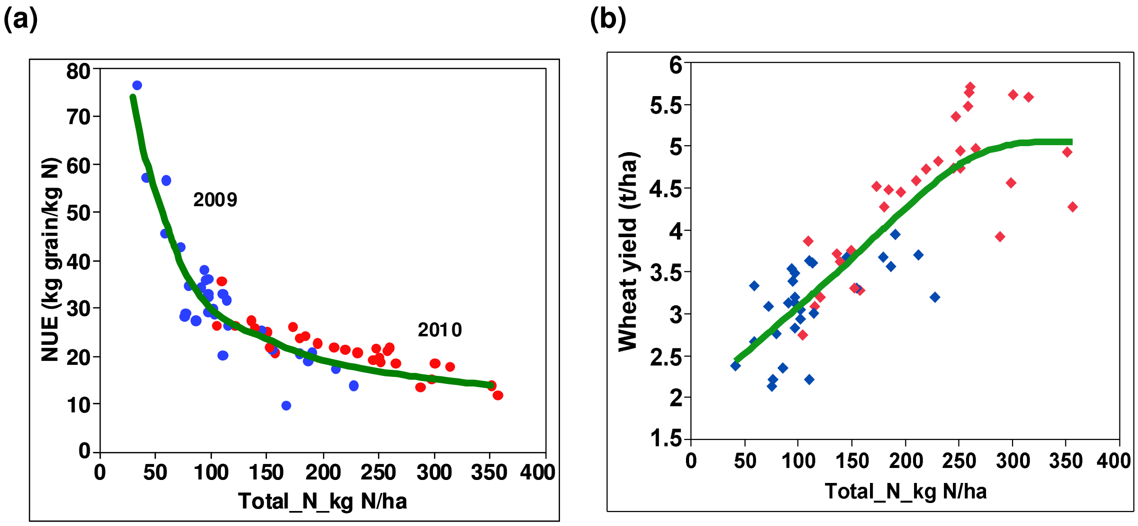

FIGURE 9 Combination of the 2009 and 2010 data for efficiency with which crop nitrogen is converted to grain (a) and the absolute yield relative to crop nitrogen (b)

These graphs show the data corresponds well and provides a useful guide to the production output and efficiency limits that can be expected with regard to nitrogen and wheat yields across a reasonably broad nitrogen and yield range.

Yield response to total applied nitrogen

The 2010 wheat yield map is shown in Figure 10. As shown in Table 2, the correlation between the NDVI and the final yield (r=0.82) is significant from a statistical and agronomic management point of view. While there was some minor frost damage, yields during 2010 were not water limited and, excepting the sand ridges, 85% of the crop was able to reach or exceed the yield targets. With such conditions, it is good to see that the data taken from the reflectance sensors during the season could be relied on to provide information relevant to final crop production.

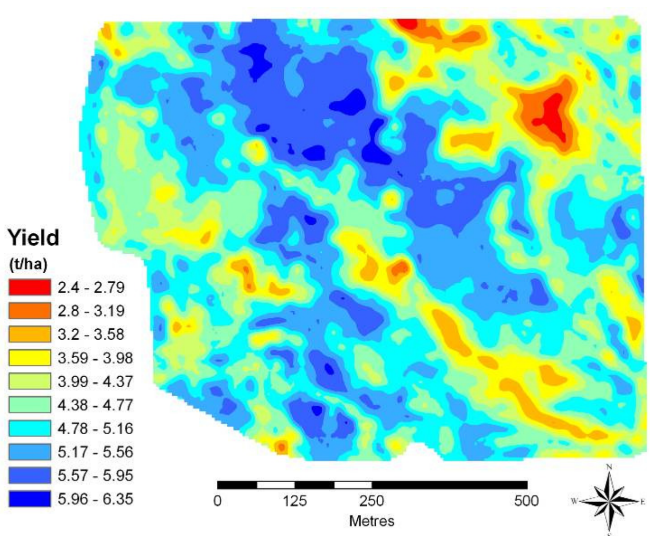

FIGURE 10 Wheat yield map for the 2010 season

The average response of the crop to the different rates of nitrogen fertiliser is shown in Figure 11.

The original four classes have been used for the analysis to explore whether there are significant differences between the two Classes (1 and 4) that were combined for fertiliser management.

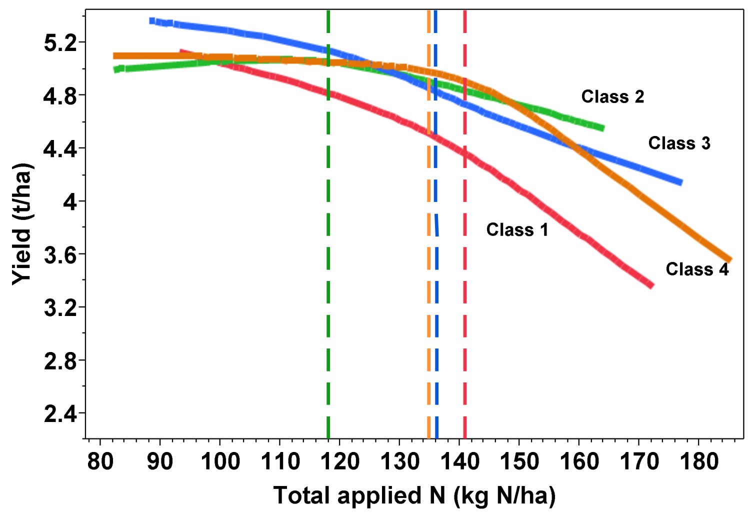

FIGURE 11 Wheat yield response to applied nitrogen fertiliser for each management class. The average applied for each class is shown by the correspondingly-coloured dashed line.

As can be seen from Figure 11, the responses for Class 1 and 4 are quite different. While Class 1 may be small, it appears that chasing greater yields with more nitrogen fertiliser may not be warranted in this case. Classes 2 and 4 appear to be more similar in response and may be a better choice for combination in any future management.

All the classes appear to have received more nitrogen than was considered optimum for their final yield, however, the frost during late September may have held back yield, which would have contributed to this result.

Three traditional blanket applications in this season would have seen 138kg/ha of nitrogen applied to the paddock. The average application for Classes 1, 3 and 4 were close to this rate, but in Class 2, 20kg/ha has been saved with no yield penalty.

Results from the other two paddocks will be combined to provide greater analysis of the response from the Classes and help direct any changes to management.

Summary

The current sensing systems can assess the vegetative production (DM and shoots/m2) and 'health' of the crop, which can help diagnose establishment and growth issues. Ground truthing can help calculate the amount of nitrogen-uptake.

The relative amounts of nitrogen in the crop, predicted by the sensors, follows the pattern expected from the different amounts of soil nitrogen before fertiliser application. This certainly lends itself to directing variable rate fertiliser applications where in-season differences are detected.

In non-water-limited seasons it appears the prediction of later season nitrogen uptake patterns from surveys performed earlier during the season is robust, which has encouraging implications for successful in-season nitrogen management.

Who was involved?

Thanks to Farmer Co-operators Mark Harmer and Adam Inchbold, P Baines Agronomy, The Australian Centre for Precision Agriculture at The University of Sydney and the Riverine Plains Inc Research Subcommittee. Crop sensing hardware was donated by gps-Ag.

Grower/Regional feedback:

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