Measuring, monitoring and understanding soil water holding properties to increase risk management, grower confidence and grain yield improvement, resulting in increased returns to grain growers.

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GROWER: N DUANE, R HOLMES, B KUPSCH

Location: Yandanooka, Mingenew, Irwin/Allanooka

Soil Type: Red deep loamy duplex, red loamy earth, duplex sandy gravel

GSR (24th Apr-Sept):
Duane: 185.1mm
Holmes: 220.4mm
Kupsch: 133mm

Paddock History:

2014 – Duane: Lupins
Holmes: Canola
Kupsch: Canola

Paddock Avg Yield:
Duane 2.9t/ha
Holmes 1.9t/ha
Kupsch 1.8t/ha

Plot Size: 2.0m x 20m

Trial Size: Small plot

Sowing Date:
Duane: 30th April
Holmes: 29th April
Kupsch: 3rd May

Sowing Rate: 80kg/ha

Sowing Machinery: Cone seeder, knife points and press wheels

Variety: Mace

PADDOCK INPUTS

Fertiliser
At seeding: All trials sown with Super at P rates equivalent to grower paddock application.

Post N: All applied 17th June 2015

SECTION A. SOIL TEST RESULTS

Soil results from sampling prior to seeding were used for soil characterization and to set the parameters in Yield Prophet and Crop Manager. The third yield prediction model analysed in this project, Ipaddock Yield, does not use soil test data, only historical yields and rainfall.

Table 1. Duane, Red deep loamy duplex

DEPTH	N	P	K	S	pH ($CaCl_2$)	OC%
0 – 10cm	13	26	135	10.8	5.5	0.47
10 – 20cm	10	33	151	11.0	4.7	0.33
20 – 30cm	9	16	118	21.6	4.7	0.21
30 – 40cm	8	5	91	31.1	4.8	0.12
40 – 50cm	9	3	71	36.6	5.0	0.11
50 – 80cm	6	3	62	24.8	5.5	0.11

Table 2. Holmes, Red loamy earth

DEPTH	N	P	K	S	pH ($CaCl_2$)	OC%
0 – 10cm	13	31	239	9.8	5.9	0.46
10 – 20cm	24	23	168	11.1	4.7	0.36
20 – 30cm	9	12	177	9.9	5.7	0.30
30 – 40cm	2	8	177	7.3	6.1	0.27
40 – 50cm	2	6	208	9.5	6.5	0.27
50 – 80cm	2	5	220	7.9	6.5	0.25

Table 3. Kupsch, Duplex sandy gravel

DEPTH	N	P	K	S	pH ($CaCl_2$)	OC%
0 – 10cm	13	9	55	3.6	5.7	1.04
10 – 20cm	7	6	42	10.7	6.1	0.57
20 – 30cm	5	4	37	13.5	6.2	0.29
30 – 40cm	4	4	30	10.7	6.3	0.22
40 – 50cm	3	3	35	7.2	6.5	0.19
50 – 80cm	3	3	48	9.9	6.5	0.17

WHY DO THE TRIAL?

The research aimed to develop a concept that growers can easily implement and access during the growing season, a concept that will provide them with real time information and improve confidence in crop performance and yield potential. This will allow growers to allocate nutritional inputs and market their grain based on informed knowledge.

When soil Nitrogen levels are tested to depth close to sowing, accurate soil profile nitrogen is known at seeding. Plant available nitrogen can be then be modeled at sowing to develop a Nitrogen response curve (as shown in Section C), allowing informed growers to tailor nitrogen applications to a range of estimated yields, increasing their level of risk management and reducing the risk of either under or over fertilizing a particular soil type.

The next peace of the jigsaw is to know what the likely final yield will be. Yield Estimation tools such as Yield Prophet, iPaddock Yield and the old water use efficiency calculators such as French & Shultz equations are all useful tools in predicting final yield. As part of this research an evaluation of these tools has been conducted.

In the evaluation the models were run retrospectively based on the previous 10 years of rainfall and paddock yield data for each research paddock in the project. A yield estimate was produced from each model as at the 31st July, for each of the 10 years in the historical data. Yield estimate accuracy was calculated and below are estimate accuracy figures from the Duane site.

1. Yield Prophet (APSIM)	58% accuracy
2. French & Shultz (Brocken Stick)	62% accuracy
3. iPaddock Yield	72% Accuracy

The more accuracy / confidence we have in the final yield estimate, the greater the ability to play the season with Nitrogen applications and maximize grain yield and profitability in any given season. Each season is different so an understanding of soil water holding capacity and plant available moisture in the soil throughout the season is essential to be able to estimate yield and tailor nitrogen applications. The knowledge and accuracy, thus confidence, that we have in this area is increasing rapidly.

Each site in the project went through the following process:

A) Selection, soil type characterization and identification of water holding parameters

B) Crop Lower Limit (CLL) and Drained Upper Limit (DUL) determined for each soil using results of particle size analysis

C) Installation of a soil moisture probe to a depth of 80cm and implementation of a replicated nitrogen rate response trial

D) Registeration for Yield Prophet and real time data from the probe fed into Crop Manager

E) Rainfall was recorded by a gauge on each probe which fed into Crop Manager

F) Comparison of actual Yield and quality data against estimations in yield prediction models.

KEY MESSAGES:

- With the current climate trending to decreased seasonal rainfall, all 1% increases in productivity are important.
  - Increases in productivity can come from increased yield, more efficient application of inputs, or more timely grain marketing.
  - Knowledge of the soil water holding properties, the time when the crop is taking up the most water from the soil and the current yield estimation models allows growers to market grain with more confidence pre harvest.
  - Tools such as Yield Prophet, iPaddock Yield, soil moisture Probes and water use efficiency models are all very useful in assisting to predict grain yields with a relatively high level of confidence when accurately set up.
  - In this project "iPaddock Yield" provided the greatest level of accuracy in predicting final grain yield on July 31st 2015.
  - When there is confidence in the early to mid-season yield prediction combined with accurate soil Nitrogen testing and modeling, there is a greater chance of maximizing profits from applied nitrogen.

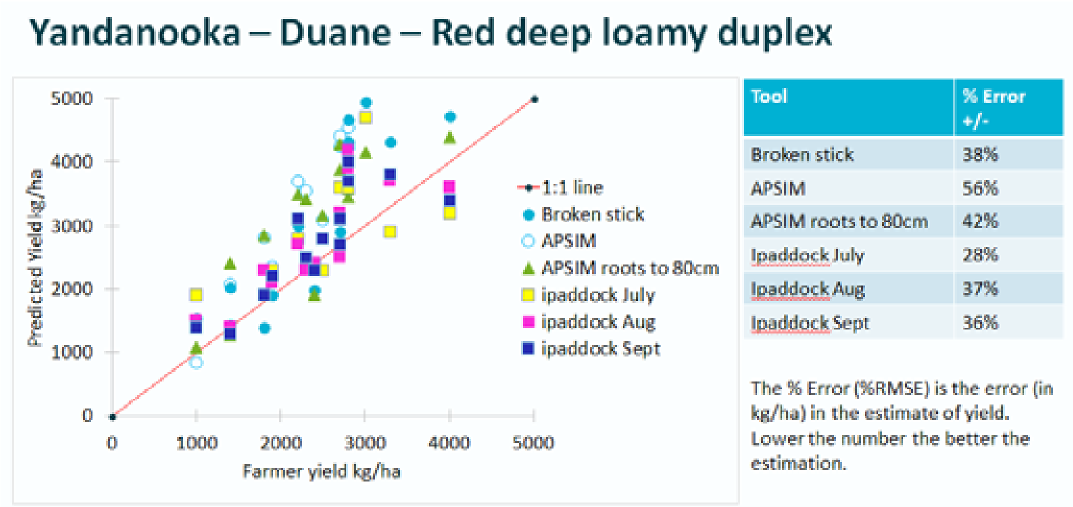
PADDOCK PREDICTIONS AND ACTUAL YIELD:

Table 4, Grower Estimate of point yield, Season Yield Estimates, iPaddock Yield and Actual yield.

SITE	DUANE (t/ha)	HOLMES (t/ha)	KUPSCH (t/ha)
Grower Estimate- 8/6/15	2.8	2.3	2.2
Yield Prophet- 3/6/15	2.7	1.5	2.2
Yield Prophet- 3/7/15	2.5	2	2.8
Yield Prophet- 14/7/15	1.8	1.8	2.6
Yield Prophet- 5/8/15	3	2.3	2.9
Yield Prophet- 27/8/15	3.4	2.4	2.8
iPaddock- 27/8/15	2.6	1.9	1.8
iPaddock- 30/9/15	2.1	2	2.3
iPaddock- 30/10/15	1.9	2	2.3
iPaddock- 16/11/15	2.2	2	2.3
Paddock Average	2.9	1.9	1.8
Plot Actual	3.4	2.2	2

Measuring, monitoring and understanding soil water holding properties to increase risk management, grower confidence and grain yield improvement, resulting in increased returns to grain growers continued.

Figure 1. Yield prediction evaluation from Duane Red Deep Loamy Duplex soil type, models run retrospectively over previous 10 years of yield and rainfall data.



COMMENT:
iPaddock yield estimated yields along the most consistent line with the smallest % error over the 10 year period.

SECTION B: SOIL WATER HOLDING CAPACITY PROPERTIES

Table 5. Duane, Red Deep Loamy Duplex

MEASUREMENT	0-100 mm	100 -200 mm	200-300 mm	300-400 mm	400-500 mm	500-600 mm	600-700 mm	700-800 mm
CLL (mm)	4.15	6.92	7.44	7.99	8.37	8.85	8.85	8.85
DUL (mm)	13.32	16.54	16.8	16.94	16.94	16.54	16.54	16.54
PAWC (mm)	9.17	9.62	9.36	8.95	8.57	7.69	7.69	7.69
Bulk Density (mm)	1.63	1.59	1.59	1.59	1.59	1.59	1.59	1.59
Total PAWC	68.74							
PAW (1/05/2015)	3.13							

Table 6. Holmes, Red Loamy Earth

MEASUREMENT	0-100 mm	100 -200 mm	200-300 mm	300-400 mm	400-500 mm	500-600 mm	600-700 mm	700-800 mm
CLL (mm)	4.53	6.09	7.51	10.06	13.57	15.94	15.94	15.94
DUL (mm)	14.09	16.35	18.12	21.07	26.35	28.88	28.88	28.88
PAWC (mm)	9.56	10.26	10.61	11.01	12.78	12.94	12.94	12.94
Bulk Density (mm)	1.61	1.59	1.57	1.52	1.47	1.44	1.44	1.44
Total PAWC	93.04							
PAW (1/05/2015)	3.12							

Table 7. Kupsch, Duplex Sandy Gravel

MEASUREMENT	0-100 mm	100 -200 mm	200-300 mm	300-400 mm	400-500 mm	500-600 mm	600-700 mm	700-800 mm
CLL (mm)	2.32	2.72	3.33	3.32	3.88	4.86	4.86	4.86
DUL (mm)	10.78	10.78	11.04	10.15	10.4	10.77	10.77	10.77
PAWC (mm)	8.46	8.06	7.71	6.83	6.52	5.91	5.91	5.91
Bulk Density (mm)	1.66	1.66	1.66	1.66	1.65	1.65	1.65	1.42
Total PAWC	55.31							
PAW (1/05/2015)	14.78							

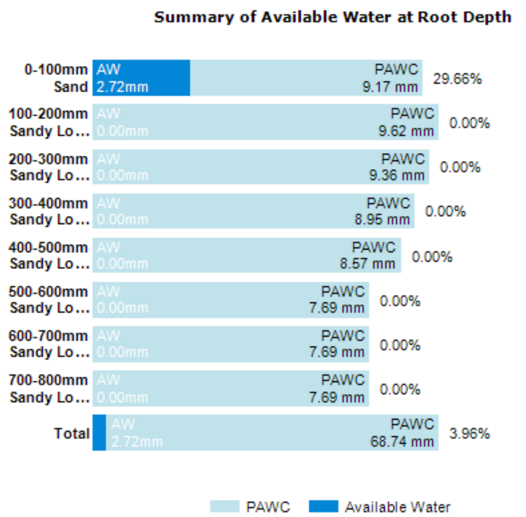
SUMMARY:

In terms of water bucket size, the red loamy earth soil at Holmes's is approximately one third larger than the other two sites with more water available to the plant roots at depth.

CLL: Crop lower limit - The water content of the soil when the crop has extracted as much water as it can. For example at 10cm the crop will never be able to access the last 2.32mm.

DUL: Drained upper limit – the water content of a soil when it is fully wet but drainage has ceased. PAWC: Plant available water capacity – DUL minus CLL (the amount of water a wheat plant can extract when the profile is full)

The soil water properties (above) have been used in the data interpretation platform "Crop Manager" throughout the season. Below is a summary of the water available to the wheat plants at Duane's on the 30th September 2015. On this date, there was 2.7mm PAW in whole profile, none at depth available to plant roots. The figure on the right is termed the "Soil Water Bucket" and displays an increased % of dark blue colour as plant available water increases following a rainfall event.



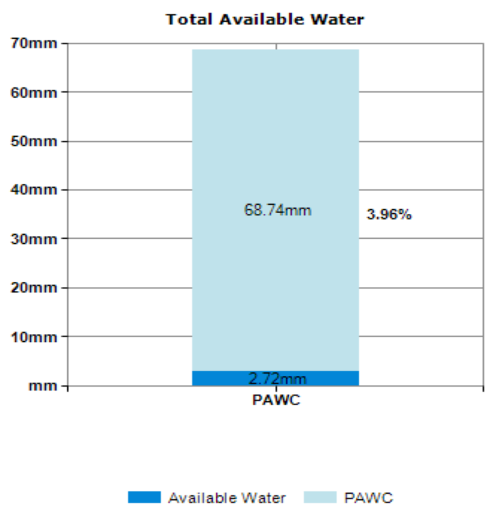


Figure 2. Summary of Available water and the soil water bucket

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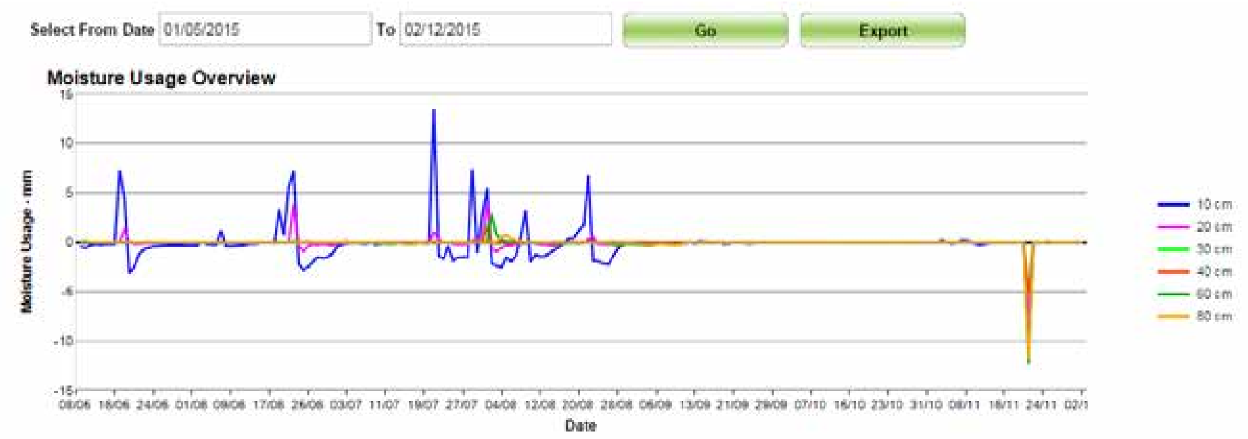

Figure 3. Moisture usage by the wheat plant at depth during the growing season.

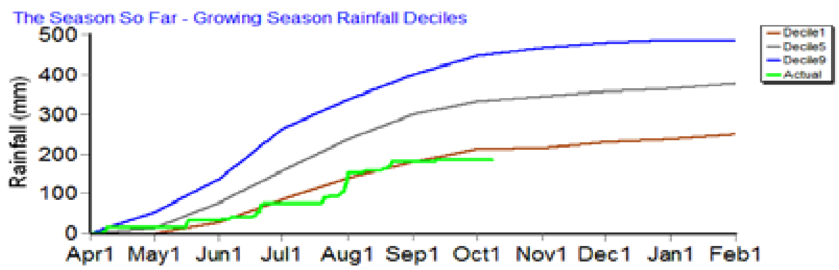

Figure 4. Season rainfall for Duane's

SECTION C. EVALUATION OF NITROGEN USAGE

Table 8. Duane harvest data and Nitrogen use efficiency

TREATMENT	YIELD t/ha	PROTEIN %	WEIGHT kg/hl	SCREENINGS %	RETURNS $/ha	RETURNS – N COSTS $/ha	RECOVERY OF FERTILISER N (%)	PNB (N)
0N	3.33	11.43	77.5	3.6	APW1 $996	$996		
20N	3.42	12.53	78.1	2.81	H2 $1028	$1,003	41.38	0.38
40N	3.40	11.73	77.2	6.15	AUH2 $985	$934	7.65	0.17
60N	3.38	11.77	77.8	3.34	APW1 $1011	$935	5.02	0.12
80N	3.29	11.93	78.1	3.77	APW1 $983	$881	2.52	0.09
100N	3.42	12.8	77.5	3.7	H2 $1028	$901	9.90	0.08
P Value	0.41	0.308	0.9	0.548				
CV%	0.15	1.401	2.004	3.967				
l.s.d 5%	2.00	0.4	0.5	4.5				

This site had 90 kg/ha Amsul (19 units) applied pre seeding

Table 9. Holmes harvest data and Nitrogen use efficiency

TREATMENT	YIELD t/ha	PROTEIN %	WEIGHT kg/hl	SCREENINGS %	RETURNS $/ha	RETURNS – N COST $/ha	RECOVERY OF FERTILISER N (%)	PNB (N)
0N	2.17	12.63	72.73	8.29	AUH2 $628	$628		
20N	2.27	12.6	73.83	6.79	AUH2 $659	$634	11.23	0.25
40N	2.27	13.3	73.87	8.98	AUH2 $657	$606	12.17	0.13
60N	2.22	13.3	72.53	7.95	AUH2 $645	$569	6.44	0.09
80N	2.27	13.8	71.4	9.24	AUH2 $659	$557	8.77	0.07
100N	2.32	14.17	71.93	9.85	AUH2 $671	$544	9.53	0.06
P Value	0.17	0.007	0.462	0.696				
CV%	0.12	0.777	3.125	4.387				
l.s.d 5%	2.00	2.5	1.7	20.7				

Table 10. Kupsch harvest data and Nitrogen use efficiency

TREATMENT	YIELD t/ha	PROTEIN %	WEIGHT kg/hl	SCREENINGS %	RETURNS $/ha	RETURNS – N COST $/ha	RECOVERY OF FERTILISER N (%)	PNB (N)
0N	1.56	11.37	75.43	4.74	AGP1 $423	$423		
20N	1.76	11.3	75.77	4.84	AGP1 $479	$454	19.46	0.17
40N	1.81	11.33	75	5.18	AGP1 $493	$442	12.46	0.09
60N	1.86	11.7	76.33	4.00	H2 $560	$482	11.95	0.06
80N	1.90	11.43	75.3	4.36	AGP1 $516	$414	8.75	0.05
100N	1.80	11.7	73.97	4.87	AUH2 $491	$364	6.00	0.04
P Value	0.009	0.351	0.117	0.018				
CV%	0.168	0.510	1.638	0.609				
l.s.d 5%	6.9	1.2	0.5	7.4				

Price Notes: All prices net delivered Geraldton and GST Exclusive Recovery of Fertiliser N (%): A measure of the % of Nitrogen recovered from additional fertilizer, 40 – 60% recovery is ideal
PNB (N): Removal to use ratio – quantifies the amount of N being removed in the produce relative to the amount supplied. A PNB less than 0.5, indicates that more N is being applied than is being removed. When PNB is above 1.0, more N is being removed than is being supplied.

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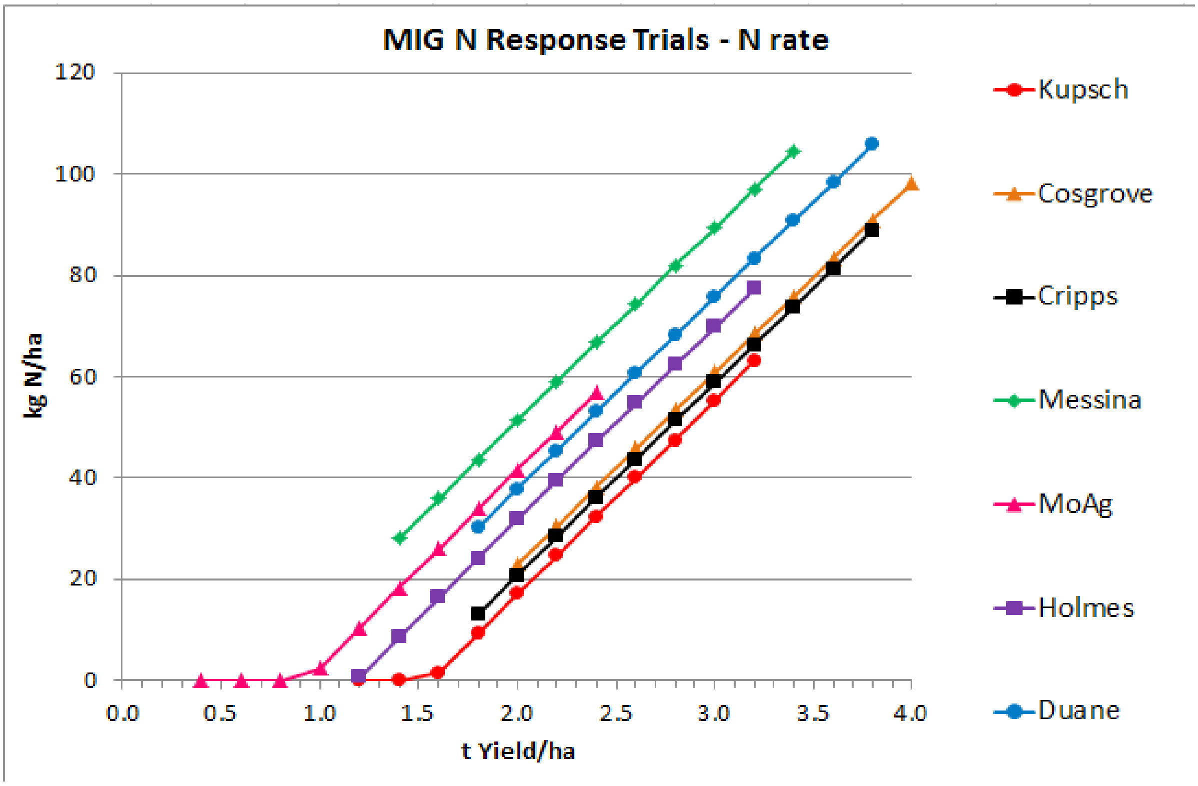

Figure 1. Nitrogen recommendations generated from Equii soil test model, shows the amount of applied soil nitrogen (kg/ ha) required to produce a range of grain yields for a number of sites. N response trials have been used to quantify the nitrogen recommendation.

COMMENTS:

- The trial component of the project was set up to develop a nitrogen response curve with rates from 0 units to 100 units of applied N. Well below average rainfall (decile 1) at all sites in 2015 resulted in soil moisture, rather than nitrogen supply, being the major limitation to grain yield at each site.
- There was very little response to applied nitrogen. The exception was the 20 units of N treatment at Duane's with the largest recovery percentage of 41%. From the PNB calculation of nutrient use efficiency, at each site more N was applied than was removed by the crop.
- The red loamy earth at Holmes's had the greatest plant available water capacity for wheat plant roots, the biggest soil water bucket.
- iPaddock yield looks at long term water use efficacy and uses a line of best fit analysis to predict yield based on rainfall received during the season at a specific time within the season . It is a comparison of previously achieved yields with a range of soil moisture levels at the same time within the season. It predicts yield based on actual farmer / paddock performance taking into account current management, soil constraints and rainfall patterns. The more historical yield and rainfall information entered into the model, the greater the accuracy will be. Essentially, past performance is utilized to predict the future yield estimates and in this project has shown to have the least variation of all models between actual yields achieved in the paddock.
- The in season nitrogen recommendations shown in the graph above indicated that there was adequate soil N to achieve the following yields – Kupsch – 1.6t/ha, Holmes 1.3t/ha, Duane 1.7t/ha.

- The Equii soil test model utilized within this project indicated that there would be no economic benefit from applied nitrogen until the yield at each site exceeded the stated figures above.
- The nitrogen recommendation graph generated pre sowing, shown above, indicated steep responses to applied nitrogen but only if the yield was to exceed the 0 N estimate. Note that the Duane site had 19 units of N applied prior to sowing trial.
- At the time of the post Nitrogen application the following yields were predicted Kupsch – 2.7T/ha, Holmes 2.0T/Ha & Duane 2.5T/ha
- Modeled Nitrogen recommendation for the predicted yield on July 3rd at the time when top up post emergent nitrogen would be applied was - Kupsch 45 units, Holmes 35 units, Duane 55 units.
- The most economic rate of Nitrogen to apply at the Duane site was 20 units producing a net return of $1003/ ha, note that this site had 19units of N applied pre sowing across all treatments so the 20 units was actually 40 units of applied N which the fertilizer model recommended to produce 2.2 T/Ha, the final yield was 3.4T/Ha. At this site the additional 1.2T/ha yield came from the 54 units of soil N identified in the profile down to 80cm with the pre sowing soil test. This shows the importance of deep soil Nitrogen testing to identify how much deep soil N is likely to be available pre sowing and then adjusting the in season nitrogen recommendations accordingly. Because the exact rooting depth and amount of soil N that can be accessed is not always known, an estimate of the amount of soil N that can be utilized is required, the amount of which will vary from season to season depending on the rainfall patterns.
- At the Holmes site 20 units of applied N produced a partial GM of $634/Ha, whilst increasing the applied N to 40 units the GM dropped to $606/ Ha as there was no yield increase above 20 units of applied N at this site. At this site 52 units of soil N was identified in the top 80cm at sowing restricting the response to applied N with the decile 1 rainfall and very dry hot finish to the season.
- 60 units of applied N was the most profitable treatment at the Kupsch site returning a GM of $482/ ha with a yield of 1.86T/ha. The 40 units of N treatment resulted in a very similar yield to the 60 units of N treatment, was downgraded to GP due to high screenings and low protein thus reducing final GM.
- Maximum N recovery was achieved at 20 units at the Kupsch site, 20 units at the Duane site, while at the Holmes site it was at 40 units, after this point at each site the additional yield generated from each additional unit of applied N declined.
- The point at which maximum N recovery is achieved is not generally the most economic rate to apply N. The point shows that the crop is still very responsive to additional N, and this forms the N response curve. The most economic point on this curve will be were the curve flattens out. At this point, additional profit from one extra unit of applied N is equal to two times the value of that unit applied N.

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