FINAL REPORT

April 2016

Increasing Profitability through the Utilisation of Combined Technologies to Target Input Strategies to Productive Capacity of Soils – 2015 Expansion

Western Region Regional Cropping Solutions Network Fast Track Projects – Project Number 2014.04.19

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Introduction

Grain growers in the Northern Agricultural Region (NAR) of Western Australia are facing increased volatility in production levels in an environment of increasing climatic and input cost variability. This increased variability creates an elevated risk profile for all cropping businesses in the region.

There is a need for growers in the NAR to understand soil production limitations, variability and the associated targeting of inputs correctly matched to soil type, yield potential and nutritional status. Agrarian Management consultants Craig Topham and Chris Pinkney have been developing and extending the concept of allocating cropping inputs according to Plant Available Water Capacity (PAWC) based production zones (whereby production zones are defined as areas of paddocks with similar productive capacity as determined by soil type and PAWC) throughout the NAR for a number of years.

Concepts and strategies associated with the allocation of cropping inputs according to Plant Available Water Capacity (PAWC) based production zones have been validated to date through the use of extensive strip trial analysis, however there remains a need to further investigate and develop the combination of Variable Rate Technology (VRT), predictive yield and nutrition modelling in order to improve water use efficiency and hence profitability.

Objectives

This project aimed to expand upon trials conducted by Agrarian Management during the 2014 growing season, namely GRDC project 06.07.2014 Western Region Regional Cropping Solutions Network Fast Track Projects – “Increasing Profitability Through the Utilization of Combined Technologies to Target Input Strategies to Productive Capacity of Soils”.

This project expansion was initiated upon request from members of both the Mingenew and broader farming communities, amongst whom the 2014 project generated substantial

interest. Based upon these requests, the trails conducted under this project aimed to further refine the principles developed during 2014, as well as extend the work to other soil types and environments.

The project was designed to continue to address the hypothesis that greater return on investment can be achieved through targeted nutrition applications according to soil type, production zone, plant available water (PAW) and seasonal conditions.

The project aimed to ground truth through statistical analysis of small plot trials current practices of leading farmers in regards to the use of Variable Rate Technology (VRT), predictive yield modelling and nutrition modelling in improving water use efficiency and hence profitability.

This project also aimed to assist in the generation of data to extend the process of using soil moisture probe data in conjunction with Yield Prophet® (YP) simulations to assist with production decisions for different soil zones (with differing PAWC), with a particular focus on top-up nitrogen.

Trial Locations

Allanooka: Latitude -29.035507º Longitude 115.135957º
Warradarge: Latitude -30.089854º Longitude 115.462752º

Methodology

In early 2015 two appropriate trial locations were determined taking into account the availability of appropriate geophysical and production data to allow for the creation of production zones.

Trial Site 1 was located within the Mingenew Irwin Group (MIG) catchment area at Allanooka, approximately 60km south-east of Geraldton and 33km north-west of Mingenew.

Figure 1. Location of Trial Site 1 - Allanooka.

Trial Site 2 was located within the West Midlands Group (WMG) catchment area at Warradarge, approximately 60km west-southwest of Coorow and 30 Km south of Eneabba.

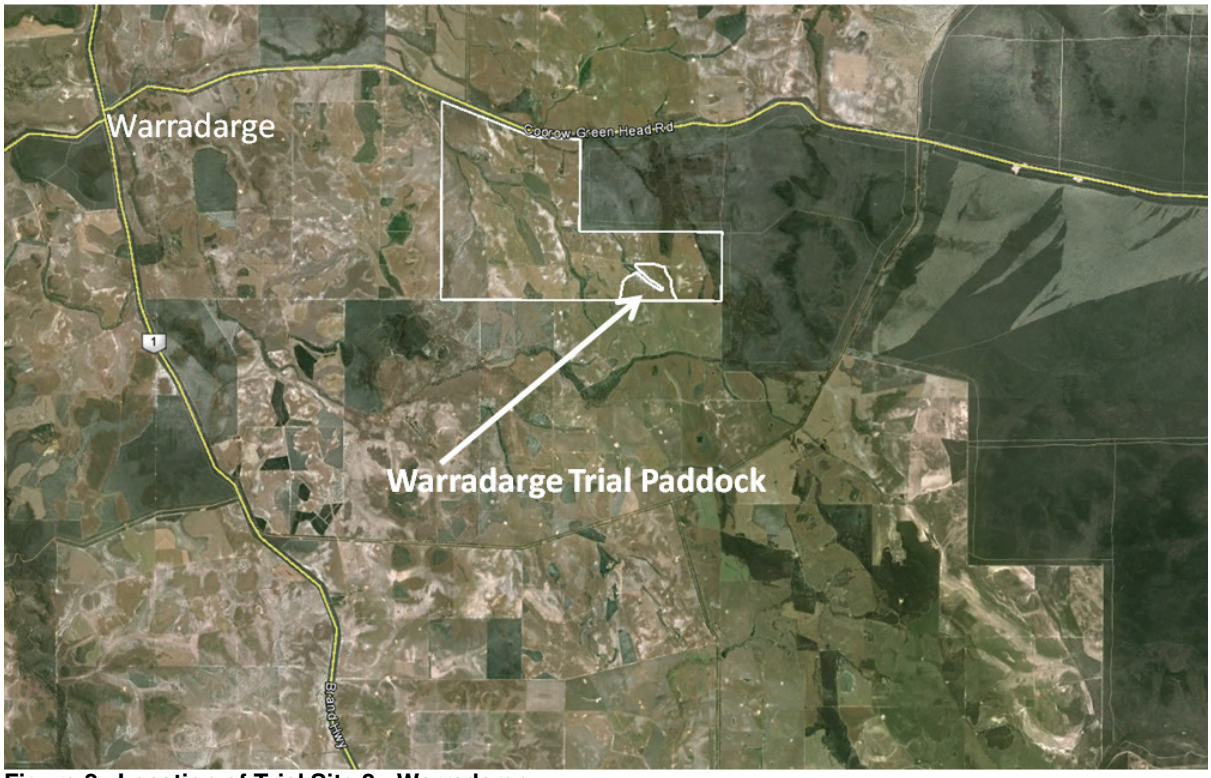


Figure 2. Location of Trial Site 2 - Warradarge

Each of the two chosen paddocks was zoned into three production zones (Low, Medium and High) based upon soil type utilising EM38 and Gamma Radiometrics. The created zones at each paddock consisted of poor pale sand, strong yellow sand and a strong sandy gravel. This range of production zones is representative of the soil type variability experienced across many sandplain paddocks across the north and west midlands.

Key differentiation between the 3 created production zones across each paddock was clay content, which in turn influenced the PAWC of each soil type. The production zones were developed based upon variation in the 0-100cm EM38 readings, Gamma Total Count and the Gamma Thorium readings. This information was collected through the EM38 and radiometrics survey with a comprehensive soil testing program conducted as part of the survey allowing the correlation between key soil chemical and physical attributes to be evaluated. Through these evaluations, excellent correlation was identified between measurable physical attributes and average profile clay percentage and Colwell K.

The strong correlations identified from the EM38 and Gamma Radiometrics survey formed the basis of the soil type zoning process. The variation in soil clay % and Colwell K in the top 30cm had the greatest influence on nutritional requirements and yield potential of each of the production zones. The low production zone in each paddock had the lowest clay and Colwell K levels, whilst the high production zones had the highest clay % as well as higher Colwell K levels. Soil test models indicated that there would be very little response to applied K on the high production zones, whilst the requirements for applied K were high on the low production zones.

The average soil clay % variation across the three production zones at each paddock had a strong influence on the soil PAWC of each of the production zones. Estimated PAWC as

determined through Yield Prophet® soil characterisations for each of the production zones at each paddock is presented below.

Allanooka Site		Warradarge Site	
Poor Zone	101mm	Poor Zone	59mm
Medium Zone	131mm	Medium Zone	113mm
Good Zone	168mm	Good Zone	168mm

Once production zones were finalised, an appropriate and representative site within each of the three production zones was identified on both properties, soil tested and a fully replicated small plot trial located within each zone.

See Figures 3 & 4 for production zone distribution across the identified paddock and individual trial site locations for both properties

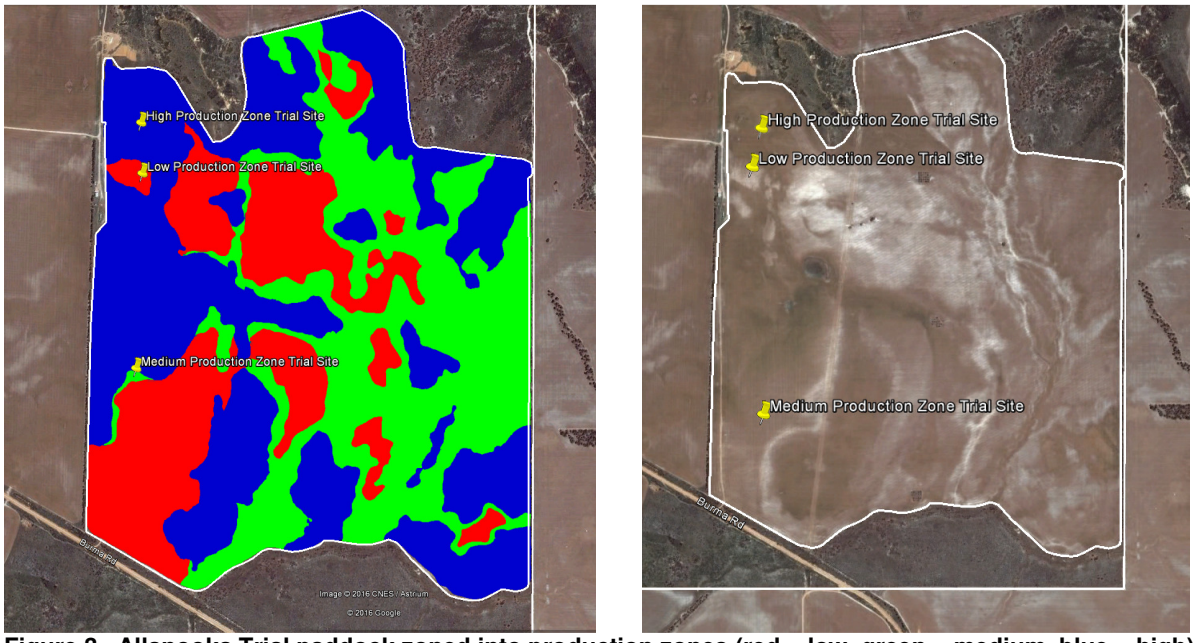


Figure 3. Allanooka Trial paddock zoned into production zones (red = low, green = medium, blue = high) with individual trial locations identified.

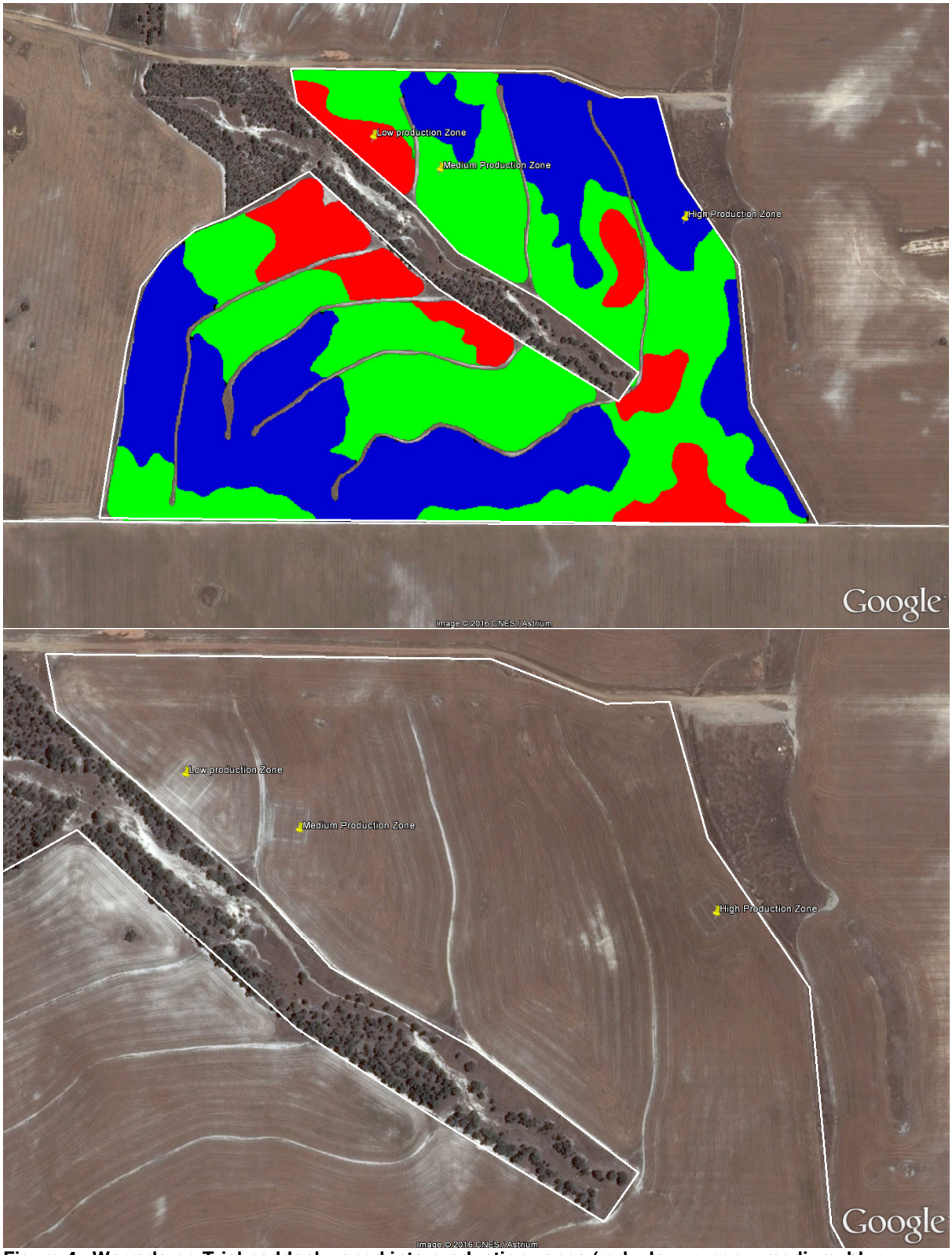


Figure 4. Warradarge Trial paddock zoned into production zones (red = low, green = medium, blue = high) with individual trial locations identified.

Nutritional status at each trial site is presented in Figure 5 overleaf.

Allanooka Site

Low Production Zone Site Soil Test Summary									
Profile	Ammonium (mg/kg)	Nitrate N (mg/kg)	Organic Carbon (%)	Colwell P (mg/kg)	PBI	Colwell K (mg/kg)	Sulfur (mg/kg)	pH (CaCl2)	AL (CaCl2)
0-10cm	< 1	8		10	5.8	< 15	2.3	5.3	0.56
10-20cm	< 1	3		14	6.3	< 15	1.4	5.1	0.70
20-30cm	< 1	2		15	5.4	< 15	1.2	4.7	0.89
30-50cm	< 1	2		18	7.1	< 15	1.2	4.7	2.12
50-100cm	< 1	1		15	7.4	< 15	2.2	4.6	4.85

Medium Production Zone Site Soil Test Summary									
Profile	Ammonium (mg/kg)	Nitrate N (mg/kg)	Organic Carbon (%)	Colwell P (mg/kg)	PBI	Colwell K (mg/kg)	Sulfur (mg/kg)	pH (CaCl2)	AL (CaCl2)
0-10cm	1	11		21	13.3	48	10.0	5.6	0.40
10-20cm	< 1	4		25	11.8	24	4.8	4.8	0.30
20-30cm	< 1	3		28	13.4	19	2.9	4.7	0.65
30-50cm	< 1	1		22	9.9	< 15	2.4	4.7	2.50
50-100cm	< 1	1		7	18.5	29	9.1	5.0	0.20

High Production Zone Site Soil Test Summary									
Profile	Ammonium (mg/kg)	Nitrate N (mg/kg)	Organic Carbon (%)	Colwell P (mg/kg)	PBI	Colwell K (mg/kg)	Sulfur (mg/kg)	pH (CaCl2)	AL (CaCl2)
0-10cm	1	6		24	19.6	115	8.1	4.9	1.63
10-20cm	< 1	4		20	28.0	109	6.8	5.2	0.29
20-30cm	< 1	4		16	36.7	149	8.1	5.0	0.27
30-50cm	< 1	2		4	73.0	175	10.2	6.1	< 0.20
50-100cm	< 1	< 1		< 2	92.2	107	17.7	6.1	< 0.20

Warradarge Site

Low Production Zone Site Soil Test Summary									
Profile	Ammonium (mg/kg)	Nitrate N (mg/kg)	Organic Carbon (%)	Colwell P (mg/kg)	PBI	Colwell K (mg/kg)	Sulfur (mg/kg)	pH (CaCl2)	AL (CaCl2)
0-10cm	1.0	7.0	0.3	16.3	5.3	18.0	3.2	6.0	0.2
10-20cm	1.0	4.0	0.1	17.0	3.5	15.0	1.5	5.5	0.3
20-30cm	1.0	2.3	0.1	16.7	5.8	15.0	0.8	5.0	0.4
30-50cm	1.0	2.0	0.1	16.7	4.8	15.0	0.6	4.7	1.0
50-100cm	1.0	4.0	0.1	3.0	64.4	72.0	14.1	5.5	0.2

Medium Production Zone Site Soil Test Summary									
Profile	Ammonium (mg/kg)	Nitrate N (mg/kg)	Organic Carbon (%)	Colwell P (mg/kg)	PBI	Colwell K (mg/kg)	Sulfur (mg/kg)	pH (CaCl2)	AL (CaCl2)
0-10cm	1.0	14.0	0.3	9.7	4.8	32.0	6.3	5.7	0.4
10-20cm	1.0	7.7	1.5	7.7	4.3	19.3	4.3	5.1	0.5
20-30cm	1.0	5.3	0.1	12.3	6.0	15.3	2.6	4.9	0.6
30-50cm	1.3	5.0	0.1	11.0	19.9	36.7	5.3	4.8	0.7
50-100cm	1.0	6.0	0.1	2.0	110.6	105.0	14.3	5.8	0.2

High Production Zone Site Soil Test Summary									
Profile	Ammonium (mg/kg)	Nitrate N (mg/kg)	Organic Carbon (%)	Colwell P (mg/kg)	PBI	Colwell K (mg/kg)	Sulfur (mg/kg)	pH (CaCl2)	AL (CaCl2)
0-10cm	1.7	9.0	0.7	13.0	24.1	115.7	5.2	5.4	0.4
10-20cm	1.7	4.7	0.4	7.0	45.8	97.0	9.8	4.8	0.7
20-30cm	1.3	4.3	0.4	3.7	140.5	171.7	31.8	5.1	0.2
30-50cm	1.0	4.0	0.3	4.0	185.9	133.7	45.7	5.5	0.2
50-100cm	1.0	6.0	0.2	2.0	200.1	88.0	37.1	5.5	0.2

Figure 5. Soil Test Summary x Trial Site

Allanooka Site – Soil Core / Soil Type Photos

Zone 1 – Low Production Zone: Poor Pale Sand

Zone 2 – Medium Production Zone: Medium – Strong Sandplain

Zone 3 – High Production Zone: Strong Sandy Gravel

Warradarge Site – Soil Core / Soil Type Photos

Zone 1 – Low Production Zone: Poor Pale Sand

Zone 2 – Medium Production Zone: Medium – Strong Sandplain

Zone 3 – High Production Zone: Strong Sandy Gravel

To enable the hypothesis to be fully addressed, trial protocols were developed for each of the three small plot trials on each property to allow assessment of:

- Profitability of targeting nutrition to zone.
- Key nutrient drivers within each zone
- The use of decision tool Yield Prophet® along with advanced nutrient modelling to enhance the in season management of post emergent nutritional inputs.

Each small plot trial was triple replicated and fully randomised and included 14 input treatments at each site on both properties.

The Wheat Variety Mace was sown on all sites.

Yield Prophet® was run throughout the season for each production zone.

A summary of the input treatments is presented in Figure 6.

Treatment Name	Treatment Description	Treatment Reason
Paddock Bulk Standard	Traditional non-VRT approach. Determined through the use of weighted averages of soil analysis data from across the entire paddock and paddock average yield potential.	Control Treatment
Zone 1 - Low Production Zone - Standard	Seed and nutritional inputs targeted to the low production zone according to soil analysis data and yield potential specific to the zone.	Allows evaluation of targeted approach to inputs based upon production zones.
Zone 2 - Medium Production Zone - Standard	Seed and nutritional inputs targeted to the medium production zone according to soil analysis data and yield potential specific to the zone.	Allows evaluation of targeted approach to inputs based upon production zones.
Zone 3 - High Production Zone - Standard	Seed and nutritional inputs targeted to the high production zone according to soil analysis data and yield potential specific to the zone.	Allows evaluation of targeted approach to inputs based upon production zones.
Zone Standard + High N	Seed and nutritional inputs targeted to the specific zone within which the trial is located as per zone standard but N application increased.	Determines key nutritional driver within zone.
Zone Standard + Low N	Seed and nutritional inputs targeted to the specific zone within which the trial is located as per zone standard but N application decreased.	Determines key nutritional driver within zone.
Zone Standard + Nil N Post Emergent	Seed and nutritional inputs targeted to the specific zone within which the trial is located as per zone standard but no N application other than that applied within the compound.	Determines key nutritional driver within zone.
Zone Standard + High K	Seed and nutritional inputs targeted to the specific zone within which the trial is located as per zone standard but K application increased.	Determines key nutritional driver within zone.
Zone Standard + Low K	Seed and nutritional inputs targeted to the specific zone within which the trial is located as per zone standard but K application decreased.	Determines key nutritional driver within zone.
Zone Standard + Nil K	Seed and nutritional inputs targeted to the specific zone within which the trial is located as per zone standard but nil K applied.	Determines key nutritional driver within zone.
Zone Standard + High NK	Seed and nutritional inputs targeted to the specific zone within which the trial is located as per zone standard but both N and K applications increased.	Determines key nutritional driver within zone.
Zone Standard + Low NK	Seed and nutritional inputs targeted to the specific zone within which the trial is located as per zone standard but both N and K applications decreased.	Determines key nutritional driver within zone.
Zone Standard + Nil NK	Seed and nutritional inputs targeted to the specific zone within which the trial is located as per zone standard but nil K and no N application other than that applied within the compound.	Determines key nutritional driver within zone.
Zone Standard + Seasonal N	Seed and nutritional inputs targeted to the specific zone within which the trial is located as per zone standard but N application varied according to decision support tool outputs.	Allows evaluation of tactical post emergent nutrient applications utilising decision support tools.

Figure 6. Input Treatment Summary.

In each treatment, all Phosphorus was banded at seeding, 50% of the potassium was banded at seeding with the remainder topdressed at 3 leaf stage (GS13) and 60% of the Nitrogen was topdressed at the 3 leaf stage (GS13) with the remainder topdressed at late tillering (GS30).

Whilst the above was utilised as a template for the determination of treatments at each trial site, in the instances where nutritional requirements of an individual site dictated that there

would be a duplication of treatments - in particular where nil K requirement was determined to be the appropriate zone standard for the high production zones at each site - then the duplicate treatment was omitted and replaced with an alternative treatment allowing for evaluation of P response.

Zone standard treatments were developed at each site utilising yield history and Yield Prophet® modelling to determine a target yield for each zone.

Target yields by zone as determined prior to seeding were:

Allanooka Site

- Production Zone 1 – Low Production Zone: 1.6T/Ha
- Production Zone 2 – Medium Production Zone: 2.6T/Ha
- Production Zone 3 – High Production Zone: 3.8T/Ha
- Paddock Bulk Standard – Control Treatment 2.8T/Ha

Warradarge Site

- Production Zone 1 – Low Production Zone: 1.6T/Ha
- Production Zone 2 – Medium Production Zone: 2.7T/Ha
- Production Zone 3 – High Production Zone: 3.8T/Ha
- Paddock Bulk Standard – Control Treatment 2.8T/Ha

Seasonal treatment inputs were determined through the use of in-season Yield Prophet® modelling (60% probability utilised) to generate revised target yields prior to each post emergent nutritional application. Target yields (T/Ha) utilised for the seasonal treatments are presented below.

Allanooka Site

	Seeding 1/05/2015	GS15 12/06/2015	GS30 9/07/15
Production Zone 1	1.6	1.7	1.6
Production Zone 2	2.6	2.3	2.2
Production Zone 3	3.8	3.2	2.6

Warradarge Site

	Seeding 12/05/2015	GS15 18/06/2015	GS30 13/07/2015
Production Zone 1	1.6	1.8	1.7
Production Zone 2	2.7	2.8	2.7
Production Zone 3	3.8	4	4.1

Nutritional input levels for each treatment were determined utilising soil analysis data and Equii (Phosphorus and Potassium) and N Broadacre (Nitrogen) nutritional modelling.

Full treatment lists for each of the small plot trials are presented overleaf for both the Allanooka and Warradarge sites:

Treatment List: Allanooka - Production Zone 1 – Low Production Zone

Treatment Name		Seeding Treatments (Applied 21/5/15)			PE Treatments - Early - GS13 (Applied 17/6/15)		PE Treatments - Late - GS30 (Applied 13/7/15)	Applied Nutrients						Input Cost $/Ha
Input Treatment	Variety	Seed (kg/ha)	Agstar Extra (kg/ha)	MOP (kg/ha)	NS31 (kg/ha)	MOP (kg/ha)	NS31 (kg/ha)	N	P	K	S	Cu	Zn	
Paddock Bulk Standard	Mace	90	70	23	77	22	70	57.8	9.9	22.3	22.5	0.07	0.14	177.22
Zone 1 - Poor - Standard	Mace	100	57	32	46	31	47	38.4	8.0	31.2	15.4	0.06	0.11	156.12
Zone 2 - Medium - Standard	Mace	90	57	14	84	14	73	59.2	8.0	13.9	22.4	0.06	0.11	162.69
Zone 3 - Good - Standard	Mace	90	87	0	119	0	105	85.3	12.3	0.0	32.4	0.09	0.17	199.24
Zone 1 Standard + High N	Mace	100	57	32	81	31	70	57.3	8.0	31.2	21.7	0.06	0.11	184.25
Zone 1 - Standard + Low N	Mace	100	57	32	11	31	23	19.1	8.0	31.2	9.0	0.06	0.11	127.51
Zone 1 Standard + Nil N PE	Mace	100	57	32	0	31	0	8.0	8.0	31.2	5.2	0.06	0.11	111.02
Zone 1 Standard + High K	Mace	100	57	40	46	55	47	38.4	8.0	47.0	15.4	0.06	0.11	175.48
Zone 1 Standard + Low K	Mace	100	57	16	46	15	47	38.4	8.0	15.3	15.4	0.06	0.11	136.76
Zone 1 Standard + Nil K	Mace	100	57	0	46	0	47	38.4	8.0	0.0	15.4	0.06	0.11	118.01
Zone 1 Standard + High NK	Mace	100	57	40	81	55	70	57.3	8.0	47.0	21.7	0.06	0.11	203.61
Zone 1 Standard + Low NK	Mace	100	57	16	11	15	23	19.1	8.0	15.3	9.0	0.06	0.11	108.15
Zone 1 Standard + Nil NK	Mace	100	57	0	0	0	0	8.0	8.0	0.0	5.2	0.06	0.11	72.90
Zone 1 Standard + Seasonal N	Mace	100	57	32	55	31	37	38.0	8.0	31.2	15.3	0.06	0.11	155.64

Treatment List: Allanooka - Production Zone 2 – Medium Production Zone

Treatment Name		Seeding Treatments (Applied 21/5/15)			PE Treatments - Early - GS13 (Applied 17/6/15)		PE Treatments - Late - GS30 (Applied 13/7/15)	Applied Nutrients						Input Cost $/Ha
Input Treatment	Variety	Seed (kg/ha)	Agstar Extra (kg/ha)	MOP (kg/ha)	NS31 (kg/ha)	MOP (kg/ha)	NS31 (kg/ha)	N	P	K	S	Cu	Zn	
Paddock Bulk Standard	Mace	90	70	23	77	22	70	57.8	9.9	22.3	22.5	0.07	0.14	177.22
Zone 1 - Poor - Standard	Mace	100	57	32	46	31	47	38.4	8.0	31.2	15.4	0.06	0.11	156.12
Zone 2 - Medium - Standard	Mace	90	57	14	84	14	73	59.2	8.0	13.9	22.4	0.06	0.11	162.69
Zone 3 - Good - Standard	Mace	90	87	0	119	0	105	85.3	12.3	0.0	32.4	0.09	0.17	199.24
Zone 2 Standard + High N	Mace	90	57	14	138	14	109	88.6	8.0	13.9	32.2	0.06	0.11	206.34
Zone 2 - Standard + Low N	Mace	90	57	14	30	14	38	30.2	8.0	13.9	12.7	0.06	0.11	119.52
Zone 2 Standard + Nil N PE	Mace	90	57	14	0	14	0	8.0	8.0	13.9	5.2	0.06	0.11	86.54
Zone 2 Standard + High K	Mace	90	57	27	84	27	73	59.2	8.0	26.7	22.4	0.06	0.11	178.42
Zone 2 Standard + Low K	Mace	90	57	7	84	7	73	59.2	8.0	6.9	22.4	0.06	0.11	154.22
Zone 2 Standard + Nil K	Mace	90	57	0	84	0	73	59.2	8.0	0.0	22.4	0.06	0.11	145.75
Zone 2 Standard + High NK	Mace	90	57	27	138	27	109	88.6	8.0	26.7	32.2	0.06	0.11	222.07
Zone 2 Standard + Low NK	Mace	90	57	7	30	7	38	30.2	8.0	6.9	12.7	0.06	0.11	111.05
Zone 2 Standard + Nil NK	Mace	90	57	0	0	0	0	8.0	8.0	0.0	5.2	0.06	0.11	69.60
Zone 2 Standard + Seasonal N	Mace	90	57	14	63	14	43	42.6	8.0	13.9	16.8	0.06	0.11	137.95

Treatment List: Allanooka - Production Zone 3 – High Production Zone

Treatment Name		Seeding Treatments (Applied 21/5/15)			PE Treatments - Early - GS13 (Applied 17/6/15)		PE Treatments - Late - GS30 (Applied 13/7/15)	Applied Nutrients						Input Cost $/Ha
Input Treatment	Variety	Seed (kg/ha)	Agstar Extra (kg/ha)	MOP (kg/ha)	NS31 (kg/ha)	MOP (kg/ha)	NS31 (kg/ha)	N	P	K	S	Cu	Zn	
Paddock Bulk Standard	Mace	90	70	23	77	22	70	57.8	9.9	22.3	22.5	0.07	0.14	177.22
Zone 1 - Poor - Standard	Mace	100	57	32	46	31	47	38.4	8.0	31.2	15.4	0.06	0.11	156.12
Zone 2 - Medium - Standard	Mace	90	57	14	84	14	73	59.2	8.0	13.9	22.4	0.06	0.11	162.69
Zone 3 - Good - Standard	Mace	90	87	0	119	0	105	85.3	12.3	0.0	32.4	0.09	0.17	199.24
Zone 3 Standard + High N	Mace	90	87	0	165	0	135	110.1	12.3	0.0	40.7	0.09	0.17	236.10
Zone 3 - Standard + Low N	Mace	90	87	0	74	0	72	59.9	12.3	0.0	23.9	0.09	0.17	161.41
Zone 3 Standard + Nil N PE	Mace	90	87	0	0	0	0	12.3	12.3	0.0	8.0	0.09	0.17	90.60
Zone 3 Standard + High K	Mace	90	87	30	119	30	105	85.3	12.3	29.7	32.4	0.09	0.17	235.54
Zone 3 Standard + Low K	Mace	90	87	15	119	15	105	85.3	12.3	14.9	32.4	0.09	0.17	217.39
Zone 3 Standard + Low P	Mace	90	44	0	127	0	115	85.1	6.2	0.0	30.4	0.04	0.09	177.87
Zone 3 Standard + High NK	Mace	90	87	30	165	30	135	110.1	12.3	29.7	40.7	0.09	0.17	272.40
Zone 3 Standard + Low NK	Mace	90	87	15	74	15	72	59.9	12.3	14.9	23.9	0.09	0.17	179.56
Zone 3 Standard + High P	Mace	90	130	0	110	0	95	85.2	18.3	0.0	34.3	0.13	0.26	220.13
Zone 3 Standard + Seasonal N	Mace	90	87	0	74	0	0	36.4	12.3	0.0	16.1	0.09	0.17	126.49

Treatment List: Warradarge - Production Zone 1 – Low Production Zone

Treatment Name		Seeding Treatments (Applied 22/5/15)			PE Treatments - Early - GS13 (Applied 18/6/15)		PE Treatments - Late - GS30 (Applied 13/7/15)	Applied Nutrients						Input Cost $/Ha
Input Treatment	Variety	Seed (kg/ha)	Agstar Extra (kg/ha)	MOP (kg/ha)	NS31 (kg/ha)	MOP (kg/ha)	NS31 (kg/ha)	N	P	K	S	Cu	Zn	
Paddock Bulk Standard	Mace	90	104	23	72	23	77	63.2	14.7	22.8	25.8	0.10	0.21	202.60
Zone 1 - Poor - Standard	Mace	100	50	28	70	27	64	50.7	7.1	27.2	19.2	0.05	0.10	166.27
Zone 2 - Medium - Standard	Mace	90	108	30	94	30	93	76.2	15.2	29.7	30.3	0.11	0.22	232.30
Zone 3 - Good - Standard	Mace	90	179	0	123	0	134	109.0	25.2	0.0	44.5	0.18	0.36	279.65
Zone 1 Standard + High N	Mace	100	50	28	100	27	81	66.1	7.1	27.2	24.3	0.05	0.10	189.06
Zone 1 - Standard + Low N	Mace	100	50	28	44	27	44	35.7	7.1	27.2	14.2	0.05	0.10	143.96
Zone 1 Standard + Nil N PE	Mace	100	50	28	0	27	0	7.1	7.1	27.2	4.6	0.05	0.10	101.28
Zone 1 Standard + High K	Mace	100	50	36	70	36	64	50.7	7.1	35.6	19.2	0.05	0.10	176.55
Zone 1 Standard + Low K	Mace	100	50	19	70	19	64	50.7	7.1	18.8	19.2	0.05	0.10	155.98
Zone 1 Standard + Nil K	Mace	100	50	0	70	0	64	50.7	7.1	0.0	19.2	0.05	0.10	132.99
Zone 1 Standard + High NK	Mace	100	50	36	100	36	81	66.1	7.1	35.6	24.3	0.05	0.10	199.35
Zone 1 Standard + Low NK	Mace	100	50	19	44	19	44	35.7	7.1	18.8	14.2	0.05	0.10	133.67
Zone 1 Standard + Nil NK	Mace	100	50	0	0	0	0	7.1	7.1	0.0	4.6	0.05	0.10	68.00
Zone 1 Standard + Seasonal N	Mace	100	50	28	86	27	122	74.9	7.1	27.2	27.3	0.05	0.10	202.16

Treatment List: Warradarge - Production Zone 2 – Medium Production Zone

Treatment Name		Seeding Treatments (Applied 22/5/15)			PE Treatments - Early - GS13 (Applied 18/6/15)		PE Treatments - Late - GS30 (Applied 13/7/15)	Applied Nutrients						Input Cost $/Ha
Input Treatment	Variety	Seed (kg/ha)	Agstar Extra (kg/ha)	MOP (kg/ha)	NS31 (kg/ha)	MOP (kg/ha)	NS31 (kg/ha)	N	P	K	S	Cu	Zn	
Paddock Bulk Standard	Mace	90	104	23	72	23	77	63.2	14.7	22.8	25.8	0.10	0.21	202.60
Zone 1 - Poor - Standard	Mace	100	50	28	70	27	64	50.7	7.1	27.2	19.2	0.05	0.10	166.27
Zone 2 - Medium - Standard	Mace	90	108	30	94	30	93	76.2	15.2	29.7	30.3	0.11	0.22	232.30
Zone 3 - Good - Standard	Mace	90	179	0	123	0	134	109.0	25.2	0.0	44.5	0.18	0.36	279.65
Zone 2 Standard + High N	Mace	90	108	30	136	30	122	99.3	15.2	29.7	38.1	0.11	0.22	266.73
Zone 2 - Standard + Low N	Mace	90	108	30	52	30	65	53.4	15.2	29.7	22.7	0.11	0.22	198.35
Zone 2 Standard + Nil N PE	Mace	90	108	30	0	30	0	15.2	15.2	29.7	9.9	0.11	0.22	141.60
Zone 2 Standard + High K	Mace	90	108	39	94	39	93	76.2	15.2	38.6	30.3	0.11	0.22	243.19
Zone 2 Standard + Low K	Mace	90	108	21	94	21	93	76.2	15.2	20.8	30.3	0.11	0.22	221.41
Zone 2 Standard + Nil K	Mace	90	108	0	94	0	93	76.2	15.2	0.0	30.3	0.11	0.22	196.00
Zone 2 Standard + High NK	Mace	90	108	39	136	39	122	99.3	15.2	38.6	38.1	0.11	0.22	277.62
Zone 2 Standard + Low NK	Mace	90	108	21	52	21	65	53.4	15.2	20.8	22.7	0.11	0.22	187.46
Zone 2 Standard + Nil NK	Mace	90	108	0	0	0	0	15.2	15.2	0.0	9.9	0.11	0.22	105.30
Zone 2 Standard + Seasonal N	Mace	90	108	30	98	30	182	106.5	15.2	29.7	40.5	0.11	0.22	277.40

Treatment List: Warradarge - Production Zone 3 – High Production Zone

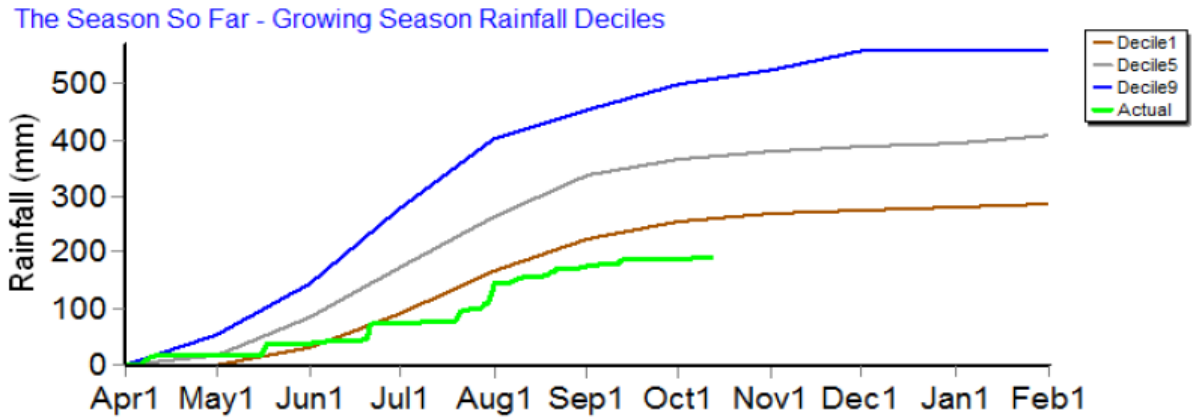
Treatment Name		Seeding Treatments (Applied 22/5/15)			PE Treatments - Early - GS13 (Applied 18/6/15)		PE Treatments - Late - GS30 (Applied 13/7/15)	Applied Nutrients						Input Cost $/Ha
Input Treatment	Variety	Seed (kg/ha)	Agstar Extra (kg/ha)	MOP (kg/ha)	NS31 (kg/ha)	MOP (kg/ha)	NS31 (kg/ha)	N	P	K	S	Cu	Zn	
Paddock Bulk Standard	Mace	90	104	23	72	23	77	63.2	14.7	22.8	25.8	0.10	0.21	202.60
Zone 1 - Poor - Standard	Mace	100	50	28	70	27	64	50.7	7.1	27.2	19.2	0.05	0.10	166.27
Zone 2 - Medium - Standard	Mace	90	108	30	94	30	93	76.2	15.2	29.7	30.3	0.11	0.22	232.30
Zone 3 - Good - Standard	Mace	90	179	0	123	0	134	109.0	25.2	0.0	44.5	0.18	0.36	279.65
Zone 3 Standard + High N	Mace	90	179	0	182	0	175	141.6	25.2	0.0	55.4	0.18	0.36	328.15
Zone 3 - Standard + Low N	Mace	90	179	0	63	0	94	76.4	25.2	0.0	33.6	0.18	0.36	231.15
Zone 3 Standard + Nil N PE	Mace	90	179	0	0	0	0	25.2	25.2	0.0	16.5	0.18	0.36	155.00
Zone 3 Standard + High K	Mace	90	179	30	123	30	134	109.0	25.2	29.7	44.5	0.18	0.36	315.95
Zone 3 Standard + Low K	Mace	90	179	15	123	15	134	109.0	25.2	14.9	44.5	0.18	0.36	297.80
Zone 3 Standard + Low P	Mace	90	107	0	152	0	136	109.0	15.1	0.0	41.2	0.11	0.21	244.28
Zone 3 Standard + High NK	Mace	90	179	30	182	30	175	141.6	25.2	29.7	55.4	0.18	0.36	364.45
Zone 3 Standard + Low NK	Mace	90	179	15	63	15	94	76.4	25.2	14.9	33.6	0.18	0.36	249.30
Zone 3 Standard + High P	Mace	90	250	0	93	0	133	108.9	35.3	0.0	47.6	0.25	0.50	314.31
Zone 3 Standard + Seasonal N	Mace	90	179	0	138	0	157	121.4	25.2	0.0	48.6	0.18	0.36	298.08

It was planned to locate a number of soil moisture probes both trial sites. Unfortunately, however, issues with the inability to transmit data brought about by insufficient mobile coverage within reasonable proximity to the trial sites severely impacted the ability to properly locate the probes. A single moisture probe was installed at the Allanooka site, however repeated vermin damage ensured that no reliable data was received and the probe was removed.

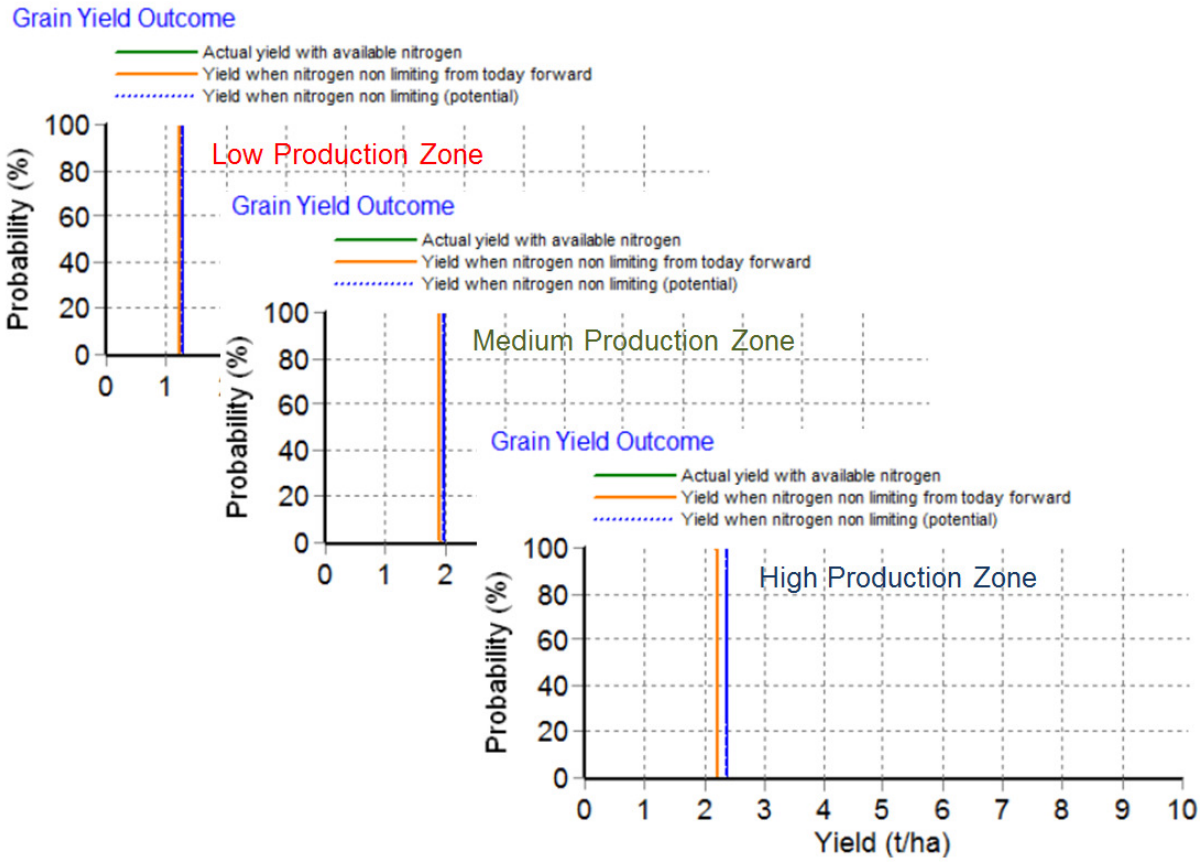
Results

1: Allanooka Site

Site Rainfall – Allanooka



Final Yield Prophet® Outputs - Allanooka



Results: Allanooka Zone 1 – Low Production Zone

Treatment Name	Applied Nutrients				Input Costs	Yield	Protein	Screenings	Stat	Grade	Return	Gross Margin
Input Treatment	N	P	K	S	$/Ha	T/Ha	%	%			$/Ha	$/Ha
Paddock Bulk Standard	57.8	9.9	22.3	22.5	177.22	0.90	10.9	4%	b-g	APW1	257.40	80.18
Zone 1 - Poor - Standard	38.4	8.0	31.2	15.4	156.12	1.01	10.5	7%	a-f	AGP1	272.70	116.58
Zone 2 - Medium - Standard	59.2	8.0	13.9	22.4	162.69	0.77	12.3	7%	efg	AUH2	214.83	52.15
Zone 3 - Good - Standard	85.3	12.3	0.0	32.4	199.24	0.76	12.6	9%	efg	AUH2	212.04	12.80
Zone 1 Standard + High N	57.3	8.0	31.2	21.7	184.25	1.03	11.3	7%	a-f	AGP1	278.10	93.85
Zone 1 - Standard + Low N	19.1	8.0	31.2	9.0	127.51	1.09	10.4	4%	a-e	APW2	311.74	184.24
Zone 1 Standard + Nil N PE	8.0	8.0	31.2	5.2	111.02	0.92	9.6	7%	a-g	AGP1	248.40	137.39
Zone 1 Standard + High K	38.4	8.0	47.0	15.4	175.48	0.93	9.9	6%	a-g	AGP1	251.10	75.62
Zone 1 Standard + Low K	38.4	8.0	15.3	15.4	136.76	0.83	11.0	7%	d-g	AGP1	224.10	87.34
Zone 1 Standard + Nil K	38.4	8.0	0.0	15.4	118.01	0.79	11.2	7%	efg	AGP1	213.30	95.30
Zone 1 Standard + High NK	57.3	8.0	47.0	21.7	203.61	1.10	11.3	6%	a-d	AGP1	297.00	93.39
Zone 1 Standard + Low NK	19.1	8.0	15.3	9.0	108.15	0.86	10.1	8%	c-g	AGP1	232.20	124.06
Zone 1 Standard + Nil NK	8.0	8.0	0.0	5.2	72.90	0.83	9.7	7%	c-g	AGP1	224.10	151.20
Zone 1 Standard + Seasonal N	38.0	8.0	31.2	15.3	155.64	0.90	10.1	7%	b-g	AGP1	243.00	87.37
								LSD	0.197	CV	12.95	

* Returns are calculated based upon best public bid 9th December 2015

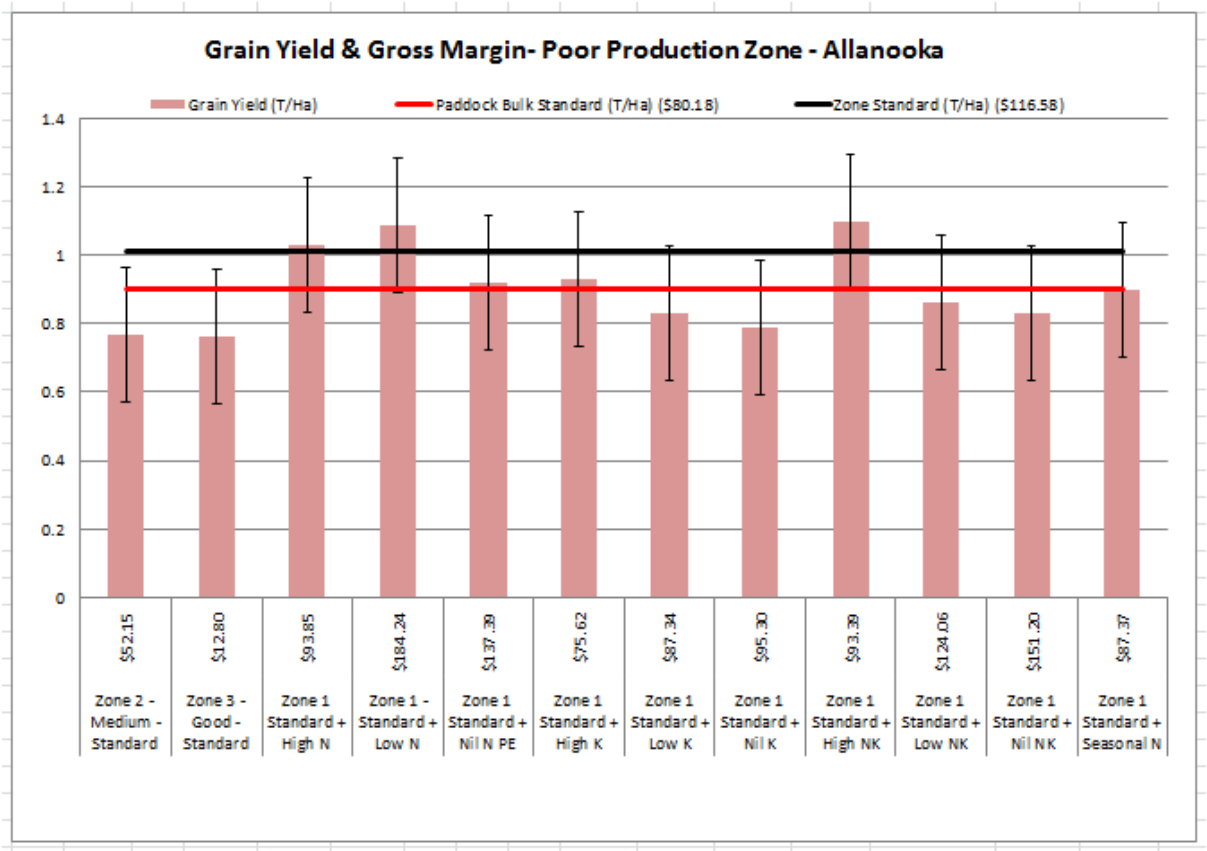


Figure 7. Grain Yield – Low Production Zone – Allanooka

Allanooka Low Production Zone 21st August 2015.

Results: Allanooka Zone 2 – Medium Production Zone

Treatment Name	Applied Nutrients				Input Costs	Yield	Protein	Screenings	Stat	Grade	Return	Gross Margin
Input Treatment	N	P	K	S	$/Ha	T/Ha	%	%			$/Ha	$/Ha
Paddock Bulk Standard	57.8	9.9	22.3	22.5	177.22	2.30	10.8	5%	a-e	APW1	657.80	480.58
Zone 1 - Poor - Standard	38.4	8.0	31.2	15.4	156.12	2.23	11.1	5%	b-e	APW1	637.78	481.66
Zone 2 - Medium - Standard	59.2	8.0	13.9	22.4	162.69	2.51	12.6	4%	a	H2	727.90	565.22
Zone 3 - Good - Standard	85.3	12.3	0.0	32.4	199.24	2.12	13.2	7%	de	AUH2	591.48	392.24
Zone 2 Standard + High N	88.6	8.0	13.9	32.2	206.34	2.26	13.2	6%	a-e	AUH2	630.54	424.21
Zone 2 - Standard + Low N	30.2	8.0	13.9	12.7	119.52	2.33	10.9	5%	a-d	APW1	666.38	546.86
Zone 2 Standard + Nil N PE	8.0	8.0	13.9	5.2	86.54	2.07	9.1	6%	e	AGP1	558.90	472.36
Zone 2 Standard + High K	59.2	8.0	26.7	22.4	178.42	2.30	11.1	6%	a-e	AGP1	621.00	442.59
Zone 2 Standard + Low K	59.2	8.0	6.9	22.4	154.22	2.29	11.1	7%	a-e	AGP1	618.30	464.09
Zone 2 Standard + Nil K	59.2	8.0	0.0	22.4	145.75	2.44	12.5	4%	ab	H2	707.60	561.86
Zone 2 Standard + High NK	88.6	8.0	26.7	32.2	222.07	2.41	13.9	4%	ab	H1	751.92	529.86
Zone 2 Standard + Low NK	30.2	8.0	6.9	12.7	111.05	2.38	10.3	5%	abc	APW2	680.68	569.63
Zone 2 Standard + Nil NK	8.0	8.0	0.0	5.2	69.60	2.14	9.7	5%	cde	ASW1	603.48	533.88
Zone 2 Standard + Seasonal N	42.6	8.0	13.9	16.8	137.95	2.43	10.5	5%	ab	APW1	694.98	557.03
								LSD	0.251	CV	6.49	

* Returns are calculated based upon best public bid 9th December 2015

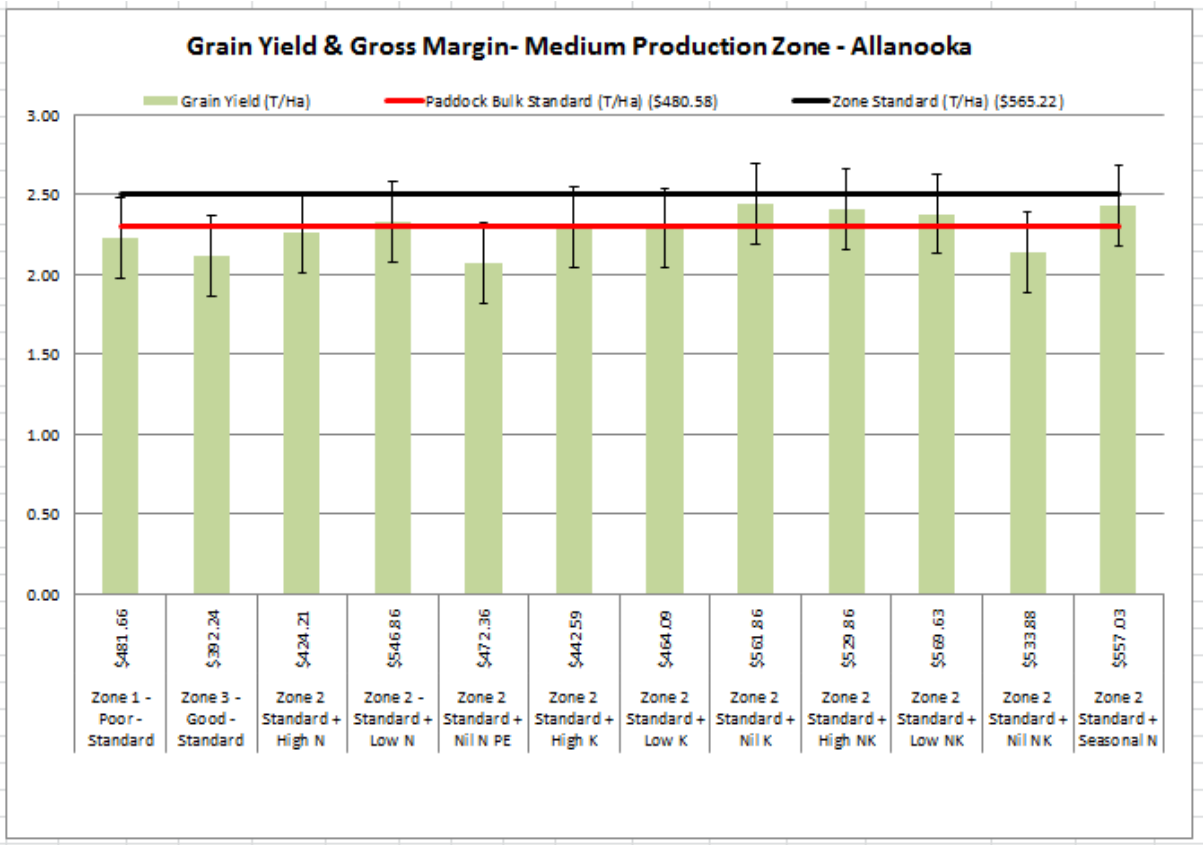


Figure 8. Grain Yield – Medium Production Zone - Allanooka

Allanooka Medium Production Zone 21st August 2015.

Results: Allanooka Zone 3 – High Production Zone

Treatment Name	Applied Nutrients				Input Cost	Yield	Protein	Screenings	Stat	Grade	Return	Gross Margin
Input Treatment	N	P	K	S		t/ha	%	%			$/Ha	$/Ha
Paddock Bulk Standard	57.8	9.9	22.3	22.5	177.22	3.12	12.1	4%	cde	H2	904.80	727.58
Zone 1 - Poor - Standard	38.4	8.0	31.2	15.4	156.12	2.79	11.4	3%	f	APW1	797.94	641.82
Zone 2 - Medium - Standard	59.2	8.0	13.9	22.4	162.69	3.13	12	4%	b-e	H2	907.70	745.02
Zone 3 - Good - Standard	85.3	12.3	0.0	32.4	199.24	3.30	11.9	4%	abc	H2	957.00	757.76
Zone 3 Standard + High N	110.1	12.3	0.0	40.7	236.10	3.42	12.4	5%	ab	H2	991.80	755.70
Zone 3 - Standard + Low N	59.9	12.3	0.0	23.9	161.41	3.34	11	4%	abc	APW1	955.24	793.83
Zone 3 Standard + Nil N PE	12.3	12.3	0.0	8.0	90.60	2.87	11	4%	ef	APW1	820.82	730.22
Zone 3 Standard + High K	85.3	12.3	29.7	32.4	235.54	3.22	12.2	4%	a-d	H2	933.80	698.26
Zone 3 Standard + Low K	85.3	12.3	14.9	32.4	217.39	3.15	12.4	5%	b-e	H2	913.50	696.11
Zone 3 Standard + Low P	85.1	6.2	0.0	30.4	177.87	3.25	11.9	5%	a-d	H2	942.50	764.63
Zone 3 Standard + High NK	110.1	12.3	29.7	40.7	272.40	3.31	12.2	4%	abc	H2	959.90	687.50
Zone 3 Standard + Low NK	59.9	12.3	14.9	23.9	179.56	3.20	11.5	5%	a-d	H2	928.00	748.44
Zone 3 Standard + High P	85.2	18.3	0.0	34.3	220.13	3.45	11.9	5%	a	H2	1000.50	780.38
Zone 3 Standard + Seasonal N	36.4	12.3	0.0	16.1	126.49	3.00	11.2	4%	def	APW1	858.00	731.51
								LSD	0.288	CV	5.4	

* Returns are calculated based upon best public bid 9th December 2015

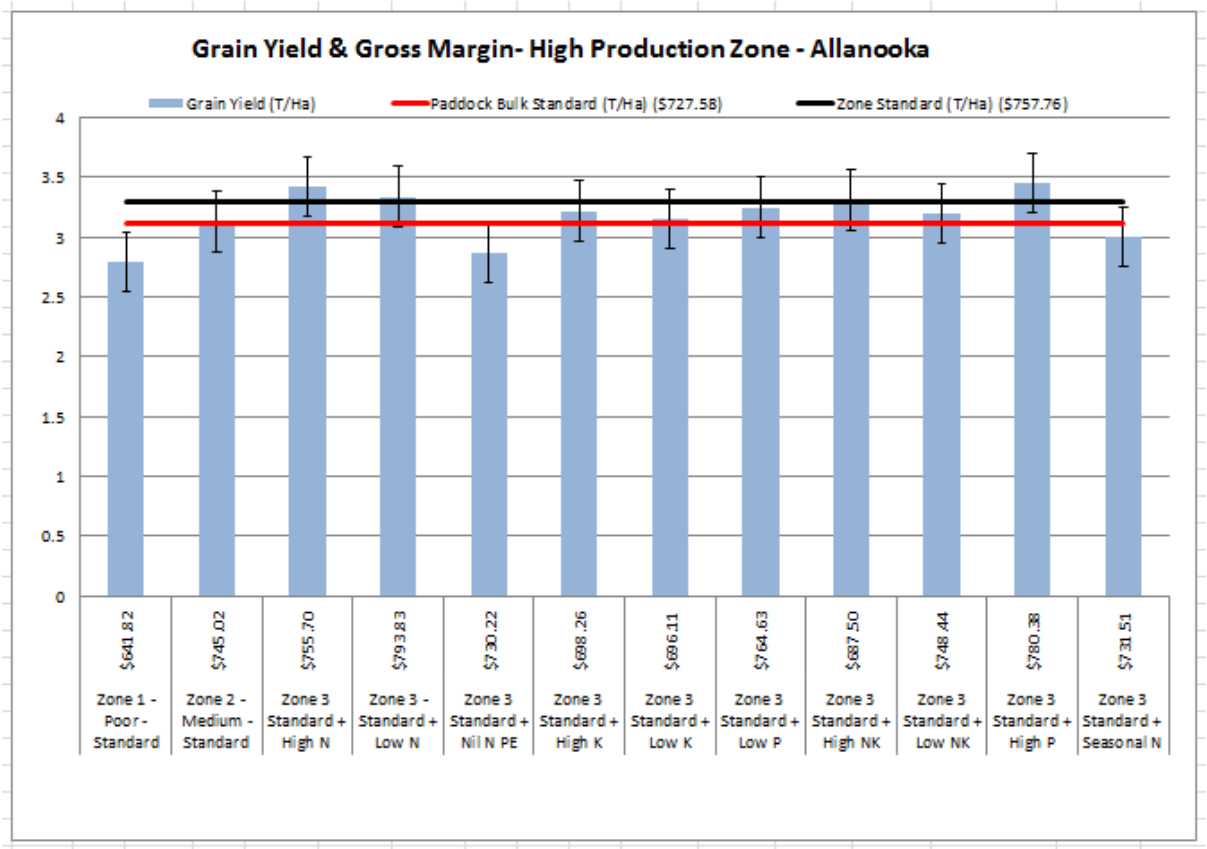
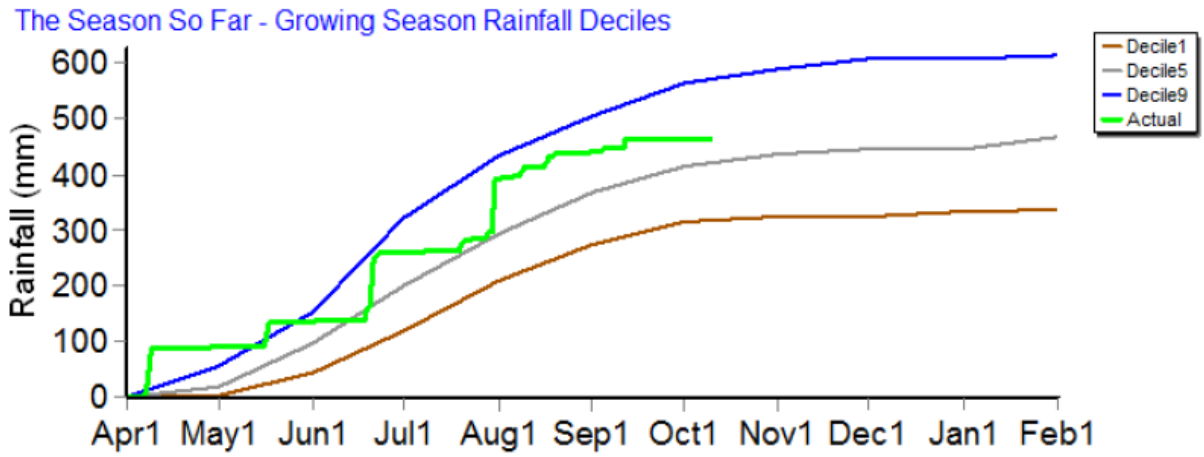


Figure 9. Grain Yield – High Production Zone - Allanooka

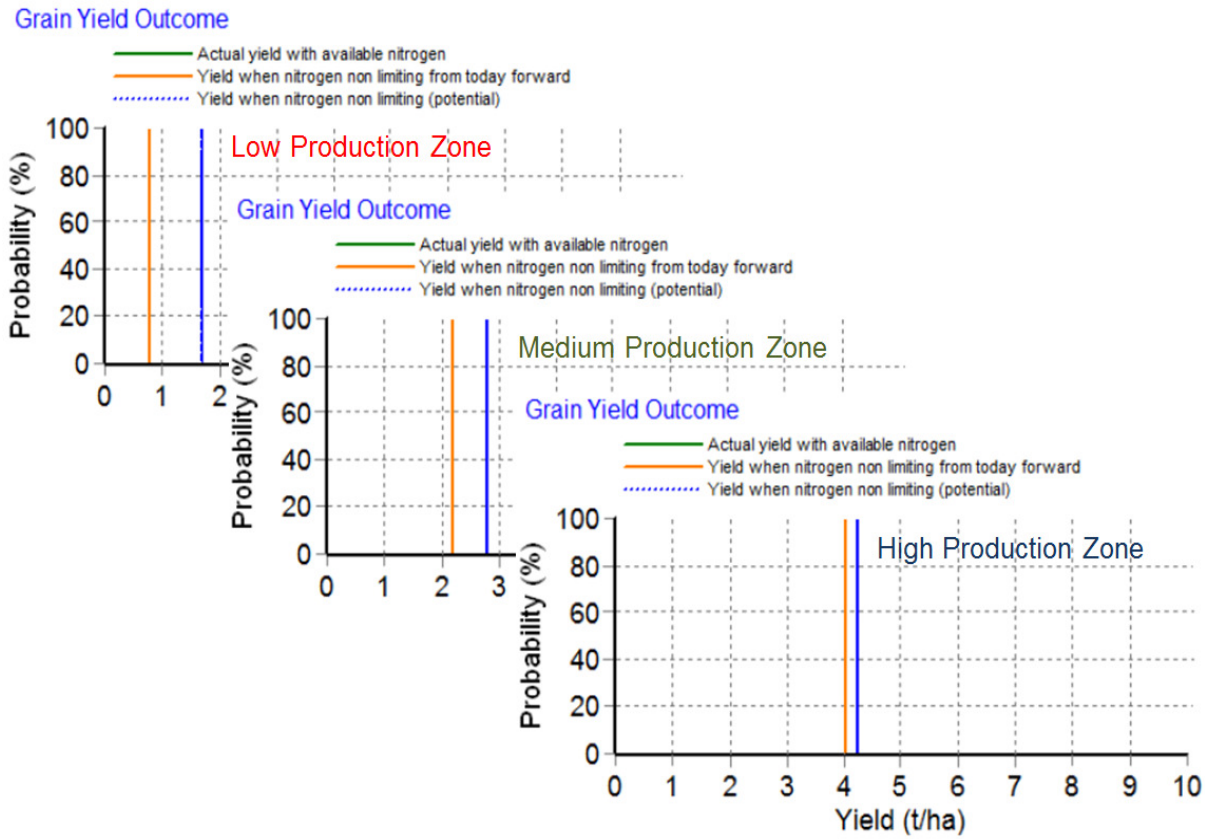
Allanooka High Production Zone 21st August 2015.

2: Warradarge Site

Site Rainfall – Warradarge



Final Yield Prophet® Outputs - Warradarge



Results: Warradarge Zone 1 – Low Production Zone

Treatment Name	Applied Nutrients				Input Costs	Yield	Protein	Screenings	Stat	Grade	Return	Gross Margin
Input Treatment	N	P	K	S	$/Ha	T/Ha	%	%			$/Ha	$/Ha
Paddock Bulk Standard	63.2	14.7	22.8	25.8	202.60	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Zone 1 - Poor - Standard	50.7	7.1	27.2	19.2	166.27	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Zone 2 - Medium - Standard	76.2	15.2	29.7	30.3	232.30	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Zone 3 - Good - Standard	109.0	25.2	0.0	44.5	279.65	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Zone 1 Standard + High N	66.1	7.1	27.2	24.3	189.06	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Zone 1 - Standard + Low N	35.7	7.1	27.2	14.2	143.96	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Zone 1 Standard + Nil N PE	7.1	7.1	27.2	4.6	101.28	N/A	N/A	N/A	N/A	N/A	1063	N/A
Zone 1 Standard + High K	50.7	7.1	35.6	19.2	176.55	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Zone 1 Standard + Low K	50.7	7.1	18.8	19.2	155.98	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Zone 1 Standard + Nil K	50.7	7.1	0.0	19.2	132.99	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Zone 1 Standard + High NK	66.1	7.1	35.6	24.3	199.35	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Zone 1 Standard + Low NK	35.7	7.1	18.8	14.2	133.67	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Zone 1 Standard + Nil NK	7.1	7.1	0.0	4.6	68.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Zone 1 Standard + Seasonal N	74.9	7.1	27.2	27.3	202.16	N/A	N/A	N/A	N/A	N/A	N/A	N/A
								LSD	N/A	CV	N/A	

*Returns are calculated based upon best public bid 9th December 2015

No reliable harvest data was achieved from the low production zone at the Warradarge site due to substantial levels of bird feeding damage across the entirety of the trial site. The trials were sown 2 weeks earlier than the surrounding farmer's paddock, meaning that the trial site matured earlier and, with a patch of large trees close by, the local cockatoo population were attracted to the maturing grain of the trial and subjected the area to substantial feeding activity. Whilst the site was harvested, all data was deemed unusable due to the level of damage sustained.

Significant visual differences were observed all season between treatments.

Warradarge Low Production Zone 26th August 2015.

Results: Warradarge Zone 2 – Medium Production Zone

Treatment Name	Applied Nutrients				Input Costs	Yield	Protein	Screenings	Stat	Grade	Return	Gross Margin
Input Treatment	N	P	K	S	$/Ha	T/Ha	%	%			$/Ha	$/Ha
Paddock Bulk Standard	63.2	14.7	22.8	25.8	202.60	2.88	10.3	7%	abc	AGP1	777.60	575.01
Zone 1 - Poor - Standard	50.7	7.1	27.2	19.2	166.27	2.78	9.4	7%	abc	AGP1	750.60	584.34
Zone 2 - Medium - Standard	76.2	15.2	29.7	30.3	232.30	2.76	10.2	7%	abc	AGP1	745.20	512.91
Zone 3 - Good - Standard	109.0	25.2	0.0	44.5	279.65	2.54	10	15%	bcd	AUW1	622.30	342.66
Zone 2 Standard + High N	99.3	15.2	29.7	38.1	266.73	3.01	10.1	7%	a	AGP1	812.70	545.97
Zone 2 - Standard + Low N	53.4	15.2	29.7	22.7	198.35	2.89	9.1	7%	abc	AGP1	780.30	581.96
Zone 2 Standard + Nil N PE	15.2	15.2	29.7	9.9	141.60	2.07	9.3	4%	e	ASW1	583.74	442.14
Zone 2 Standard + High K	76.2	15.2	38.6	30.3	243.19	2.85	10.3	6%	abc	AGP1	769.50	526.32
Zone 2 Standard + Low K	76.2	15.2	20.8	30.3	221.41	2.90	10	7%	ab	AGP1	783.00	561.60
Zone 2 Standard + Nil K	76.2	15.2	0.0	30.3	196.00	2.21	9.9	13%	de	AUW1	541.45	345.46
Zone 2 Standard + High NK	99.3	15.2	38.6	38.1	277.62	2.78	9.4	6%	abc	AGP1	750.60	472.98
Zone 2 Standard + Low NK	53.4	15.2	20.8	22.7	187.46	2.51	10.1	8%	cd	AGP1	677.70	490.25
Zone 2 Standard + Nil NK	15.2	15.2	0.0	9.9	105.30	1.88	8.9	7%	e	AGP1	507.60	402.30
Zone 2 Standard + Seasonal N	106.5	15.2	29.7	40.5	277.40	2.65	11.8	11%	abc	AUW1	649.25	371.85
								LSD	0.387	CV	8.8	

*Returns are calculated based upon best public bid 9th December 2015

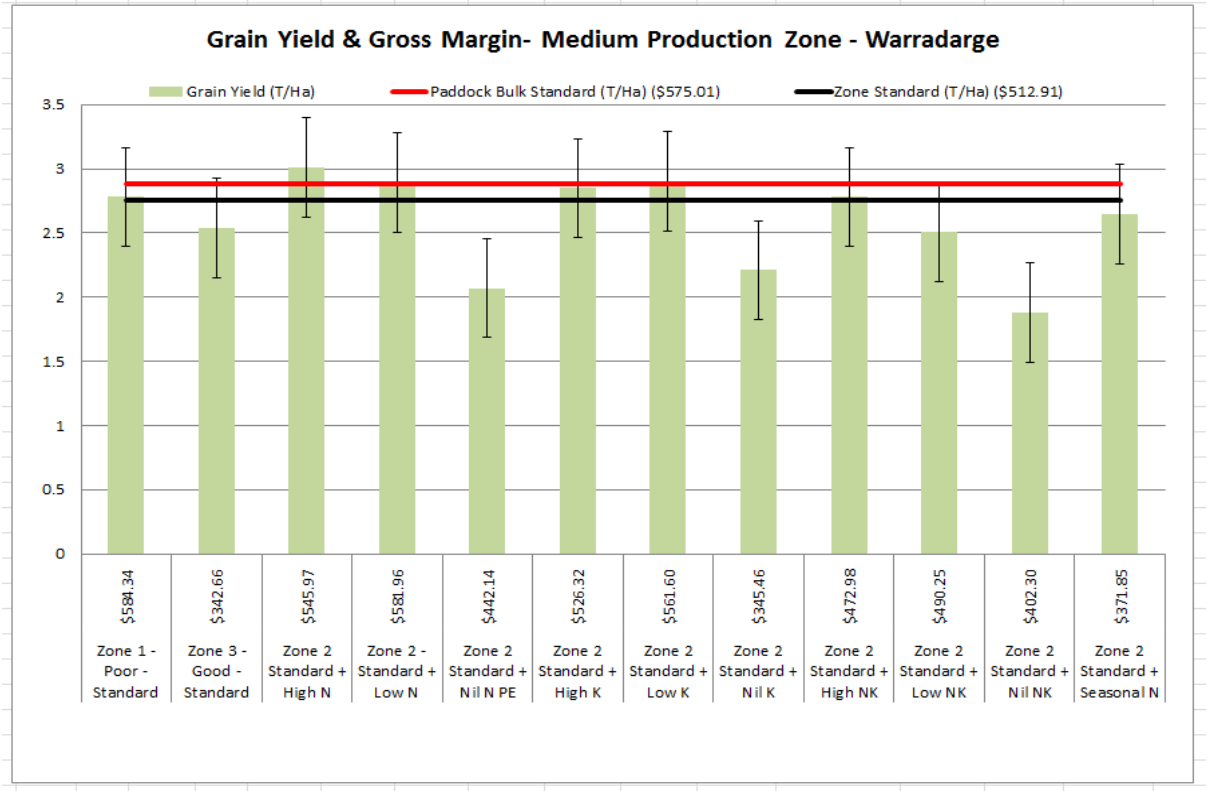


Figure 10. Grain Yield – Medium Production Zone - Warradarge

Warradarge Medium Production Zone 26th August 2015.

Results: Warradarge Zone 3 – High Production Zone

Treatment Name	Applied Nutrients				Input Costs	Yield	Protein	Screenings	Stat	Grade	Return	Gross Margin
Input Treatment	N	P	K	S	$/Ha	T/Ha	%	%			$/Ha	$/Ha
Paddock Bulk Standard	63.2	14.7	22.8	25.8	202.60	3.66	11	4%	a	APW1	1046.76	844.17
Zone 1 - Poor - Standard	50.7	7.1	27.2	19.2	166.27	3.12	11.2	4%	a	APW1	892.32	726.06
Zone 2 - Medium - Standard	76.2	15.2	29.7	30.3	232.30	3.48	11.5	3%	a	H2	1009.20	776.91
Zone 3 - Good - Standard	109.0	25.2	0.0	44.5	279.65	3.39	11.2	3%	a	APW1	969.54	689.90
Zone 3 Standard + High N	141.6	25.2	0.0	55.4	328.15	3.46	11.8	4%	a	H2	1003.40	675.26
Zone 3 - Standard + Low N	76.4	25.2	0.0	33.6	231.15	3.21	10.8	3%	a	APW1	918.06	686.92
Zone 3 Standard + Nil N PE	25.2	25.2	0.0	16.5	155.00	3.58	10.1	5%	a	APW2	1023.88	868.88
Zone 3 Standard + High K	109.0	25.2	29.7	44.5	315.95	3.64	11.7	5%	a	H2	1055.60	739.66
Zone 3 Standard + Low K	109.0	25.2	14.9	44.5	297.80	3.28	11	4%	a	APW1	938.08	640.29
Zone 3 Standard + Low P	109.0	15.1	0.0	41.2	244.28	3.36	11	3%	a	APW1	960.96	716.68
Zone 3 Standard + High NK	141.6	25.2	29.7	55.4	364.45	3.34	11.6	5%	a	H2	968.60	604.16
Zone 3 Standard + Low NK	76.4	25.2	14.9	33.6	249.30	3.35	10.9	4%	a	APW1	958.10	708.81
Zone 3 Standard + High P	108.9	35.3	0.0	47.6	314.31	3.57	11.2	3%	a	APW1	1021.02	706.71
Zone 3 Standard + Seasonal N	121.4	25.2	0.0	48.6	298.08	3.72	11.2	3%	a	APW1	1063.92	765.85
								LSD	0.551	CV	9.54	

*Returns are calculated based upon best public bid 9th December 2015

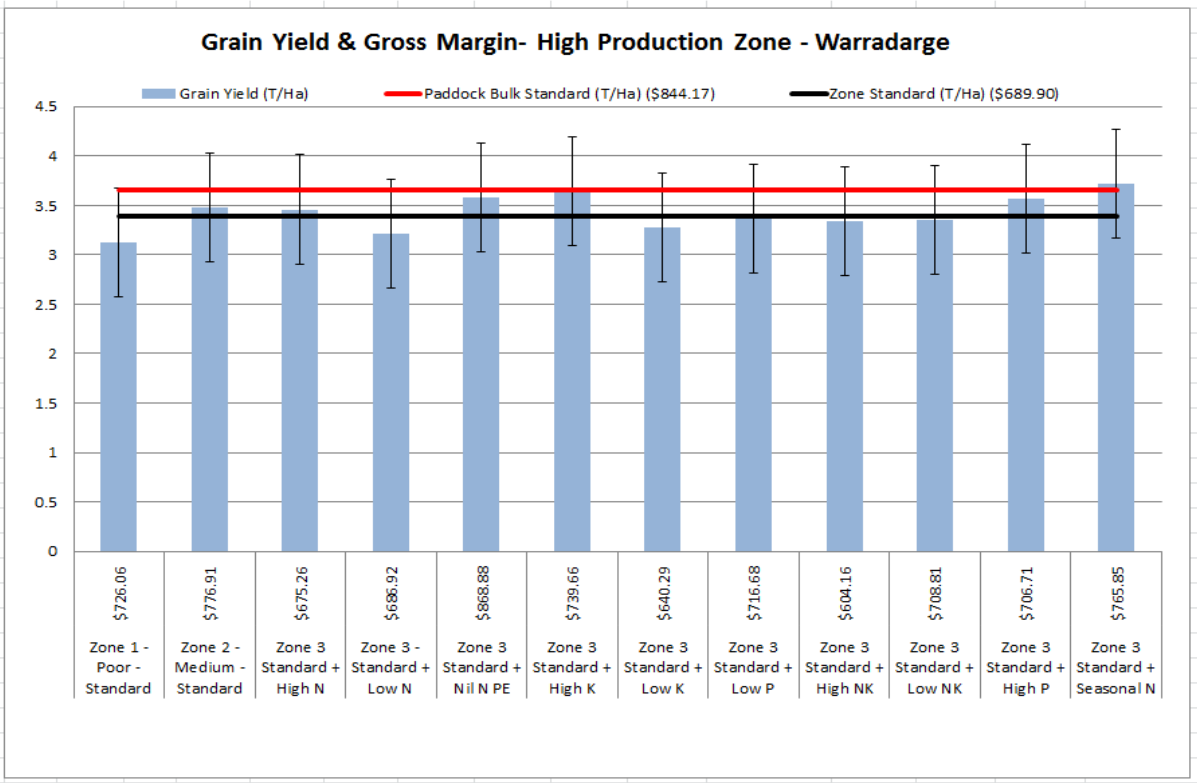


Figure 11. Grain Yield – High Production Zone - Warradarge

Warradarge High Production Zone 26th August 2015.

Discussion of Results

One rationale behind the two sites was to determine whether or not similar approaches following the same basic principles and methodology would generate similar results across the different environments.

Seasonal conditions at each site were challenging. The Allanooka site received below Decile 1 rainfall, with the rainfall occurring regularly but in small quantities. The Warradarge site, on the other hand, received Decile 6 rainfall, though the majority of this was received in just 4 substantial rainfall events through the season. Neither site received meaningful finishing rainfall after mid-August, and September and October average temperatures were in the order of 3°C above average at both sites.

Despite these challenging conditions, some meaningful results were achieved.

Yield Variation across the Zones – Enough to Justify VRT?

It is necessary to determine whether or not there was sufficient yield variation across the three production zones to justify the utilisation of a VRT program at each site. This has been addressed by comparing the Paddock Bulk Standard (control) treatment across the three different soil types at each site. Findings in this respect were:

1. There was a statistically significant difference between wheat yields across each of the three production zones at the Allanooka site. See Figure 12.

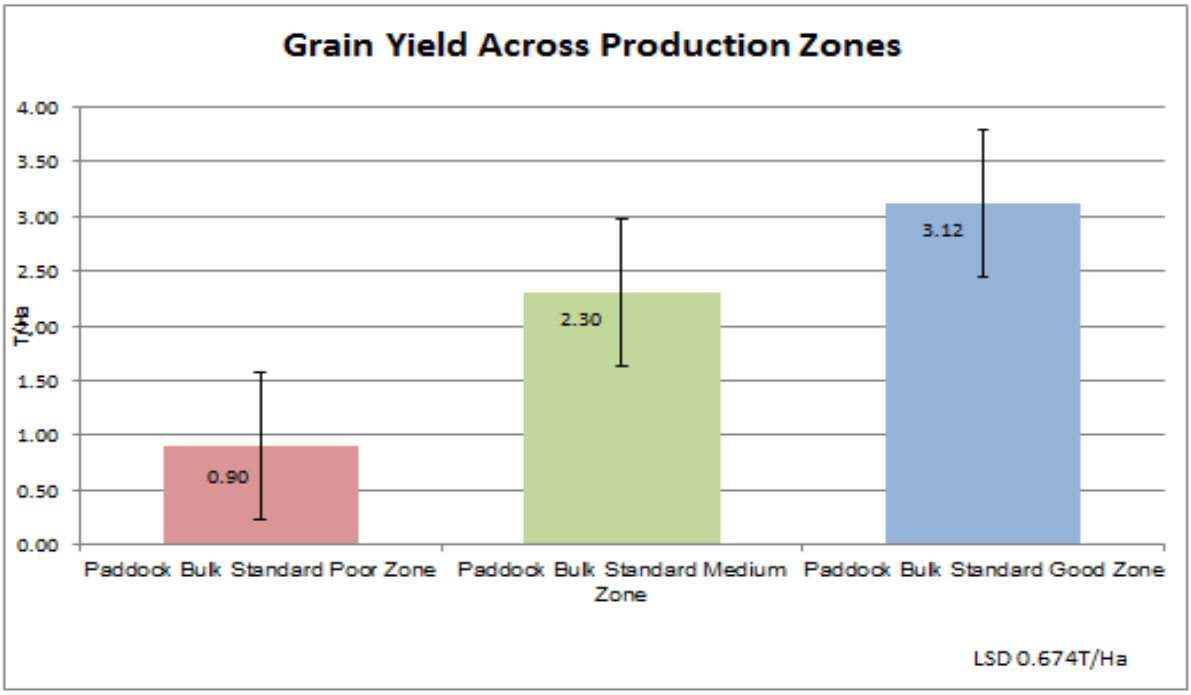


Figure 12. Yield of Paddock Bulk Standard across 3 Production Zones – Allanooka

2. Due to the loss of reliable harvest data from the Low Production Zone at the Warradarge site through bird damage, statistical analysis using the ANOVA test could not be performed. A basic t-Test was used to evaluate the difference in wheat yields between the Medium Production Zone and the High Production Zone. It was found that the difference in wheat yields between the two zones could not be deemed statistically significant at the 5% confidence level, though confidence existed at the 10% level. See Figure 13.

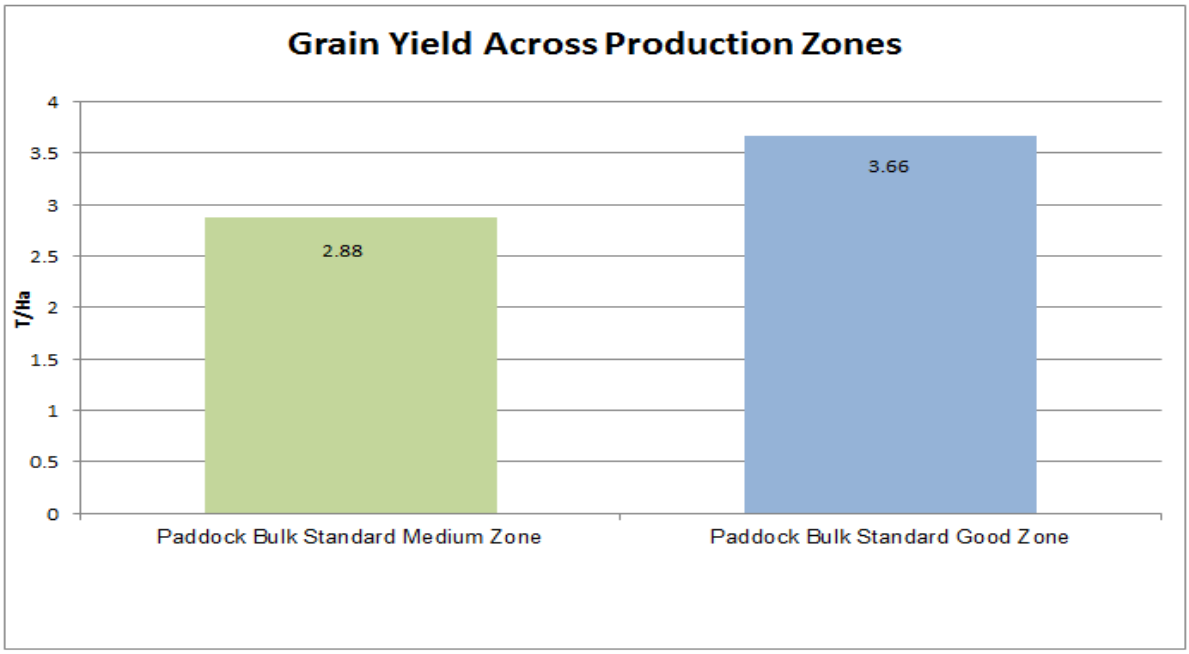


Figure 13. Yield of Paddock Bulk Standard across 2 Production Zones – Warradarge

The visual difference between the Medium and the High Production Zones was far greater than the 780 kg/Ha final yield identified at harvest. Biomass and apparent yield potential as determined visually was substantially greater in the High Production Zone throughout the season. The sharp finish to the season resulted in there not being sufficient moisture in the soil profile to finish the high biomass crop of the High Production Zone as compared to the Medium Production Zone which produced substantially lower biomass and did manage to finish – see photos below.

Difference between High (Left) and Medium (Right) Production Zones - Warradarge August 2015

Of note though, the biomass production of the Low Production Zone at Warradarge was substantially inferior to that of both the High and Medium Production Zones. Had bird damage not occurred and harvest results been meaningful, it is felt that the between zone wheat yield differences would have been significant. In the absence of significant results for the Warradarge site, however, it is necessary to treat the observed results as non-significant trends only and the bulk of discussion must be based upon the results achieved at the Allanooka site.

Low Production Zone Warradarge August 2016

Profitability of Implementing a VRT Program by Targeting Nutrition to Zone.

As illustrated in Figure 12, there was determined to be a statistically significant difference in wheat yield between each of the three zones when the same control treatment was applied at Allanooka. Where such variability exists, there is the opportunity to manipulate inputs in a targeted fashion with the view to increasing margin across each of the different zones.

The profitability of targeting nutrition to zone can be evaluated through the comparison between the targeted zone standard treatment and the Paddock Bulk Standard (control) treatments.

Firstly, however, it is necessary to determine the statistical significance between the Zone Standard Treatments and the Paddock Bulk Standard. It can be seen from the table below that whilst there are substantial yield gains associated with targeting nutritional inputs to each zone, the yield gains are not statistically significantly different across any of the Production Zones. As such, a degree of caution must be exercised when interpreting the results.

Zone	Yield Variance +/- Paddock Bulk Standard (T/Ha)	LSD Yield Variance (T/Ha)	Yield Variance Sig vs N.Sig
Low Production Zone	0.11	0.197	NS
Medium Production Zone	0.21	0.251	NS
High Production Zone	0.18	0.288	NS

Given the non-significance of the yield variances achieved, it may be appropriate to adjust any gross margin calculation back to a zero yield response, directly correlating the gross margin to input cost rather than any interaction between inputs cost and yield response. This could be considered a worst case gross margin scenario, whereas the calculated gross margin utilising the yield advantages actually achieved could be considered a best case gross margin.

Best and worst case gross margin calculations for the Allanooka site are presented below.

Zone	Input Cost Variance +/- Paddock Bulk Standard ($/Ha)	Yield Variance +/- Paddock Bulk Standard (T/Ha)	Best Case Gross Margin at Achieved Yields ($/Ha)	Worst Case Gross Margin at Zero Yield Response ($/Ha)
Low Production Zone	-$21.10	0.11	$36.40	$21.10
Medium Production Zone	-$14.54	0.21	$84.64	$14.54
High Production Zone	$22.02	0.18	$30.18	-$22.02

It is apparent that in the 2015 season at Allanooka, the implementation of a targeted nutrition strategy returned a positive gross margin across the Low and Medium Production Zones in both the best and worst case scenarios. The gross margin associated with a targeted nutrition strategy across the High Production Zone is less certain, with higher input costs

potentially leading to a negative margin were no yield benefit achieved. This is not unsurprising given the nature of the season. Targeting higher yields in a challenging year is fraught with danger and a review of strategy for these higher yielding areas may be appropriate. Given that the Northern Agricultural Region is increasingly experiencing poor finishing conditions, the strategy for many of the higher production areas that invariably produce high biomass during the season may be to ensure than Phosphorus and Potassium applications are appropriate to higher production levels but restrain from implementing anything other than a conservative Nitrogen strategy until later in the season whereupon levels of subsoil moisture and yield potential are better understood. This strategy is supported by the trial results, whereby the yield achieved at 70% N rate was virtually identical to that achieved at the standard N rate at substantially lower input cost. It is critical not to restrict yield potential through the application of insufficient early N as evidenced by the significant negative yield responses to the nil N and very low seasonal N applications.

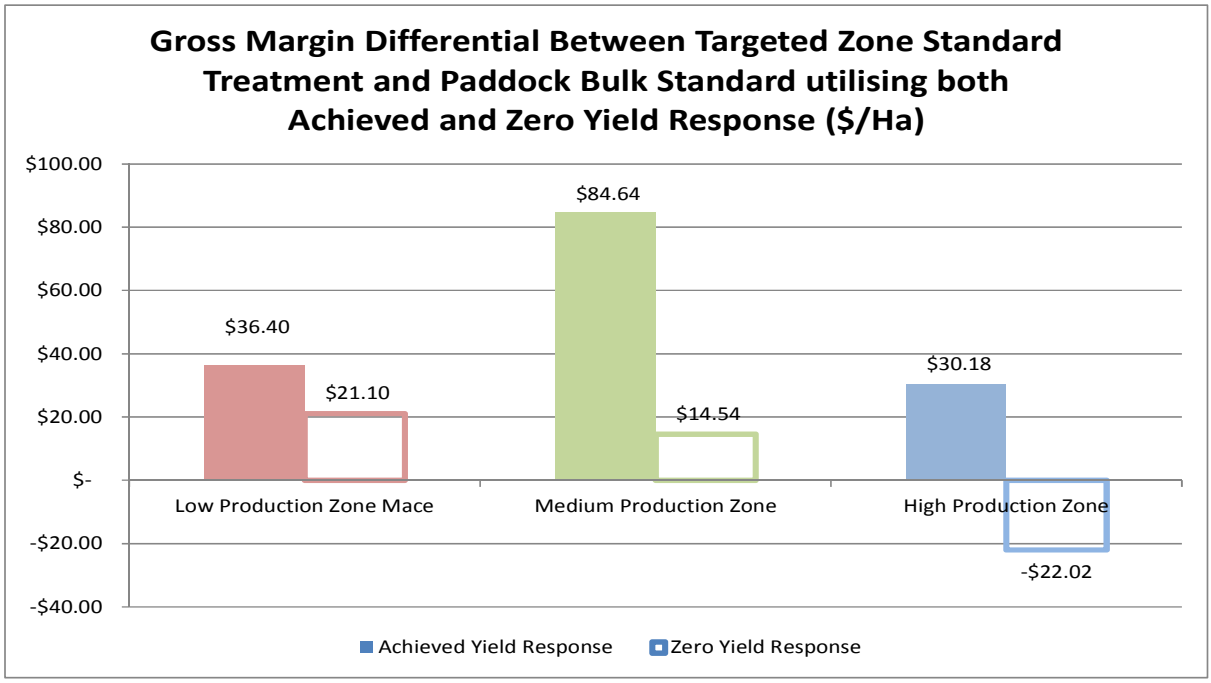
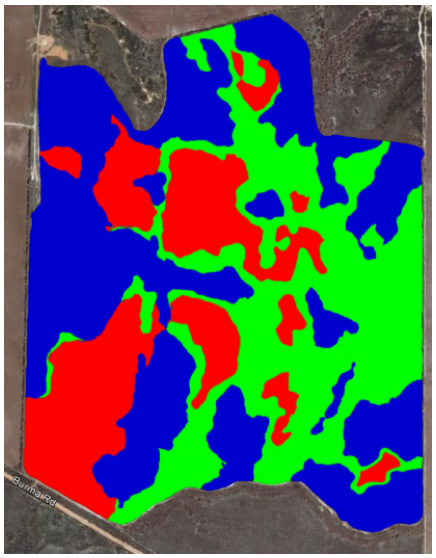


Figure 14. Gross Margin Associated with Targeting Inputs to Production Zone - Allanooka.

The calculated gross margins for the Allanooka site can be extrapolated back to a paddock level to determine the return associated with the VRT strategy across the entirety of the trial paddock.



Production Zone	Area	Gross Margin Best Case	Gross Margin Worst Case
Low Production Zone	72 Ha	$2,621	$1,519
Medium Production Zone	99 Ha	$8,379	$1,439
High Production Zone	131 Ha	$3,953	-$2,885
Total	**302 Ha**	**$14,953 $49.51/Ha**	**$73 $0.24/Ha**

Gross margin associated with implementing a VRT strategy across the Allanooka trial paddock in all likelihood lies somewhere in between the calculated best and worst case scenarios. The non-significant trends in yield achieved across the Allanooka trials would, however, suggest that the result would lie at the upper end of the two scenarios.

Of note, whilst the difference between zones could not be determined to be significant at Warradarge, similar analysis of Zone Standard vs Paddock Bulk Standard treatments generates completely different results to that achieved at Allanooka. The complete lack of any finishing rains and a particularly warm spring effectively capped treatment responses and penalised high biomass treatments. Gross margins associated with targeted nutrition strategies across the High and Medium Production Zones at Warradarge are presented in Figure 15 below.

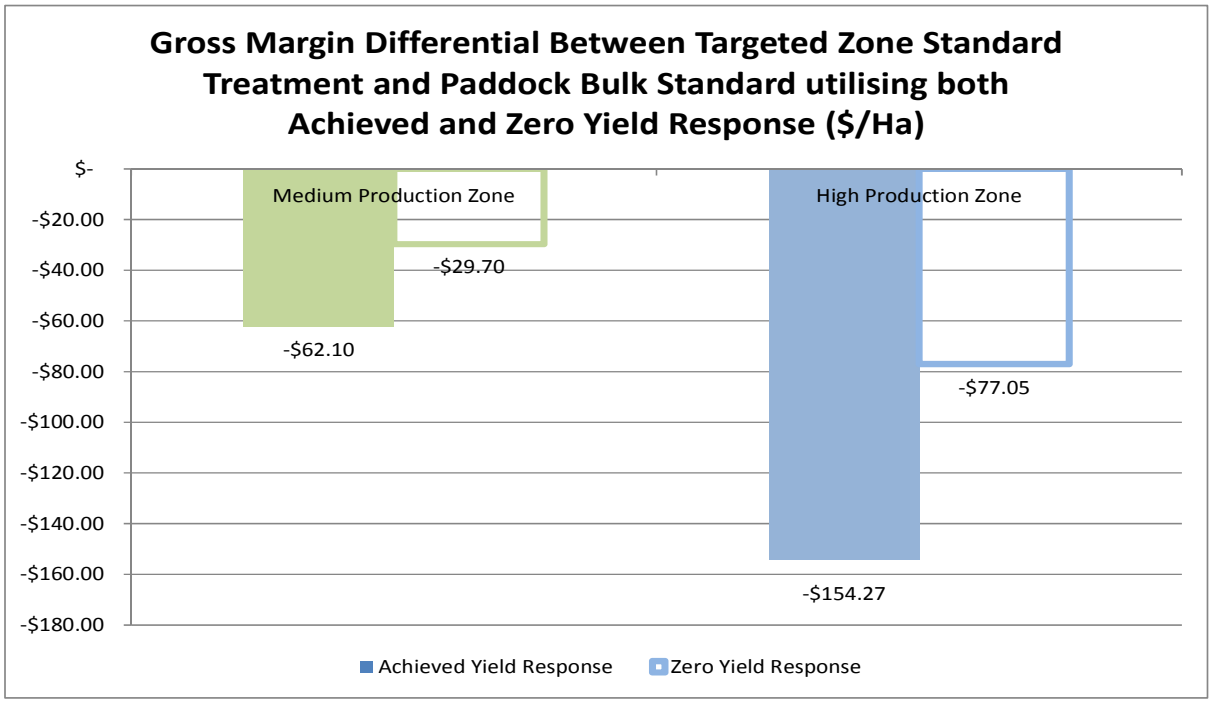


Figure 15. Gross Margin Associated with Targeting Inputs to Production Zone - Warradarge.

In each instance at Warradarge, the Zone Standard had substantially higher input levels than the Paddock Bulk Standard; hence the negative gross margins even at zero yield response. The data would suggest that the most appropriate treatments across these two zones at Warradarge given the season were zone appropriate Phosphorus and Potassium applications followed up with either low or nil Nitrogen. It is important to note that most appropriate treatments did vary across the two zones, supporting the use of a VRT strategy even in the extremely challenging season experienced in 2015.

Overall, whilst the lack of statistically significant results severely restricts the ability to generate sound conclusions, it is felt that there is enough generally supportive evidence to suggest that there are benefits associated with implementing a VRT program, though care needs to be taken in choosing the correct strategy for each Production Zone.

Key Nutrient Drivers within Production Zones.

Whilst the results achieved at the 2 trial sites varied greatly, there are a number of conclusions that can be drawn in respect to the key nutrient drivers across each Production Zone.

Unfortunately, whilst the Warradarge data is absent, the Allanooka dataset clearly indicates that potassium is the key driver on the lighter soil types represented by the Low Production Zone and characterised by low Colwell K and poor waterholding capacity.

As can be seen in Figure 16, there is no significant response to applied Nitrogen, though there is a positive trend up to 19kg/ha beyond which yield declines. There is a significant response to Potassium at 31kg/ha.

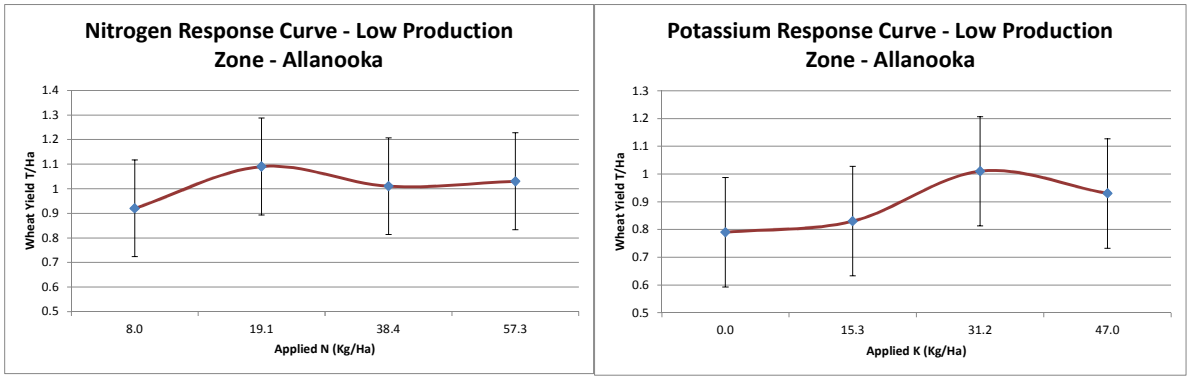


Figure 16. Nitrogen and Potassium Response Curves – Low Production Zone - Allanooka.

This is further supported by the fact that the two lowest yielding treatments across this Production Zone were the Medium Zone and High Zone standards – each treatment applying either nil or low Potassium in combination with high Nitrogen.

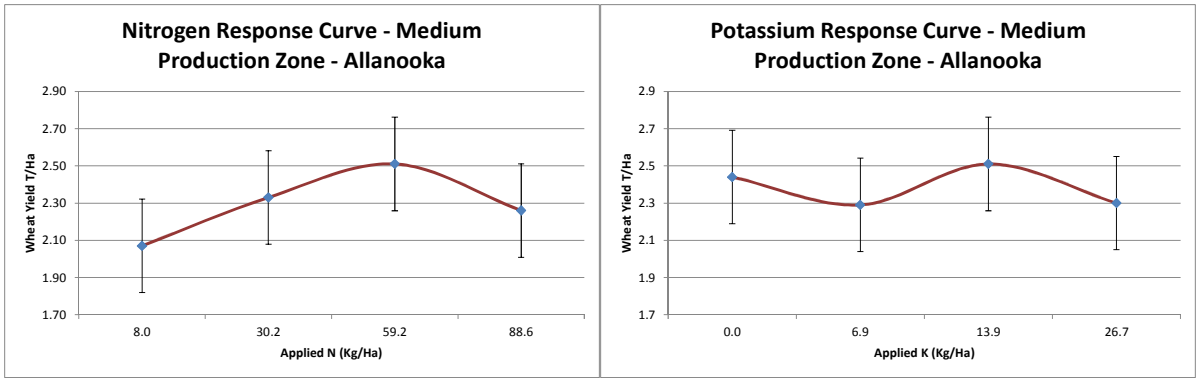


Figure 17. Nitrogen and Potassium Response Curves – Medium Production Zone - Allanooka.

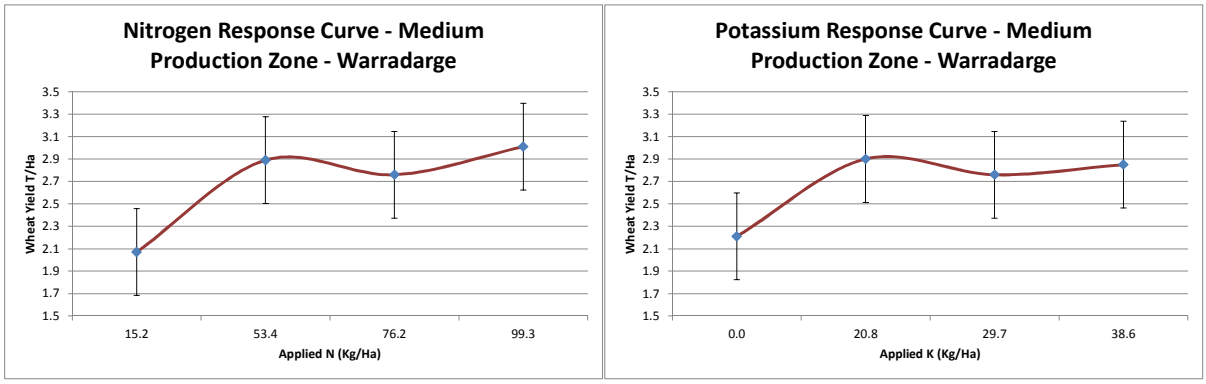


Figure 18. Nitrogen and Potassium Response Curves – Medium Production Zone – Warradarge.

Nutrient drivers in the medium to strong sandplain soil types represented by the Medium Production Zone at each location are Nitrogen and Potassium – Figure 18.

The Nitrogen response is consistent across the two sites with significant responses to the application of Nitrogen at 30kg/ha at Allanooka (with no significant difference between rates above that) and 53kg/ha at Warradarge (again, with no significant difference between rates above that). Obviously, should seasonal conditions have differed, it would have been expected that significant responses would have been achieved at the higher Nitrogen rates.

The Potassium scenario on these medium and strong sands is entirely dependent upon soil Potassium levels. The Warradarge site had lower soil Colwell K levels in the topsoil than the Allanooka site and the observed Potassium response reflected this, with a significant response to 20kg/ha applied Potassium, whereas the Allanooka site failed to show a significant response to any applied Potassium. This lack of significant response observed at Allanooka is possibly not unexpected given the relatively low yields achieved and the predicted response curve modelled upon soil data – Figure 19.

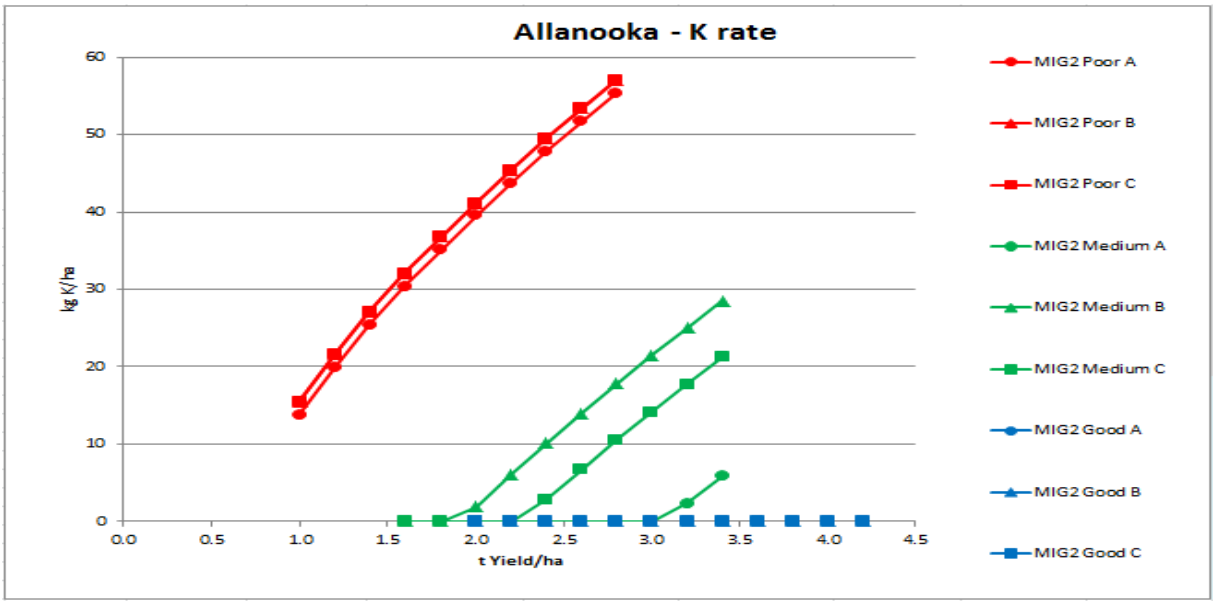


Figure 19. Modelled Potassium Response – Allanooka.

Generally, however, adequate potassium rates are required to achieve an economic response to applied nitrogen across this soil type.

In the gravels of the High Production Zones at each site, there was no response to applied Potassium. In fact, at the Warradarge site there was no significant yield response to Potassium, Nitrogen or even Phosphorus - Figures 21 and 22. There were certainly visual biomass responses to Nitrogen and, to a lesser extent, Phosphorus through the season, however the dry and warm finish to the season ensured these biomass responses were not translated to yield.

At the Allanooka site, there was a significant response to applied Nitrogen up to 60kg/ha with no additional response to rates above that – Figure 20. Like Warradarge, there was a trend towards higher yields as P rate was increased, however this was not significant and certainly not economic – Figure 22.

Nitrogen, in the presence of adequate Phosphorus, is the key nutrient driver on these soil types.

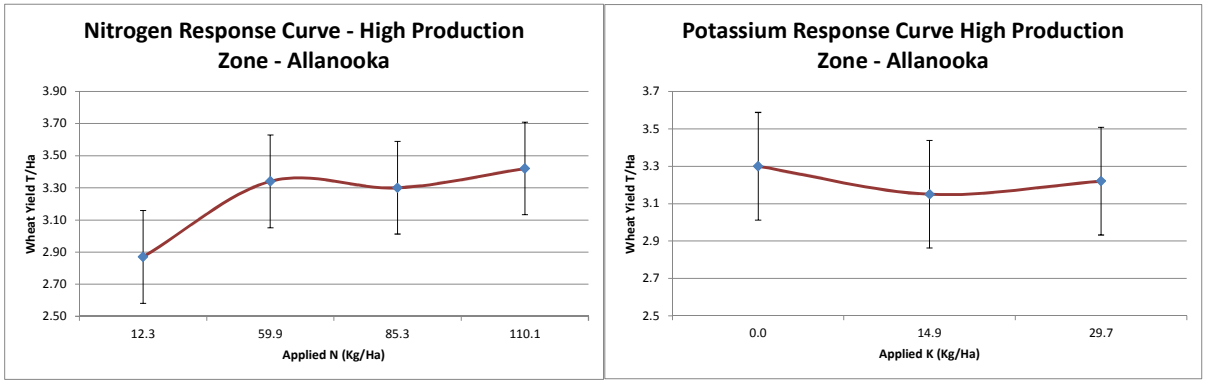


Figure 20. Nitrogen and Potassium Response Curves – High Production Zone - Allanooka.

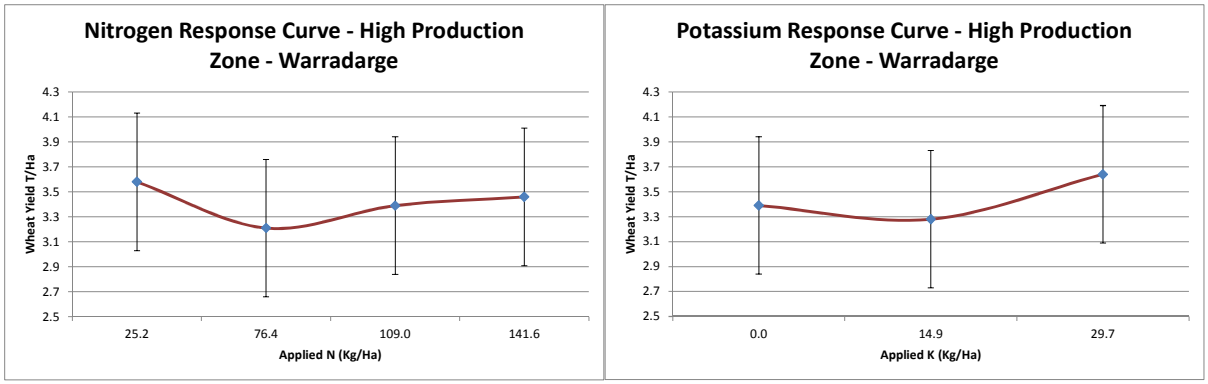


Figure 21. Nitrogen and Potassium Response Curves – High Production Zone - Warradarge.

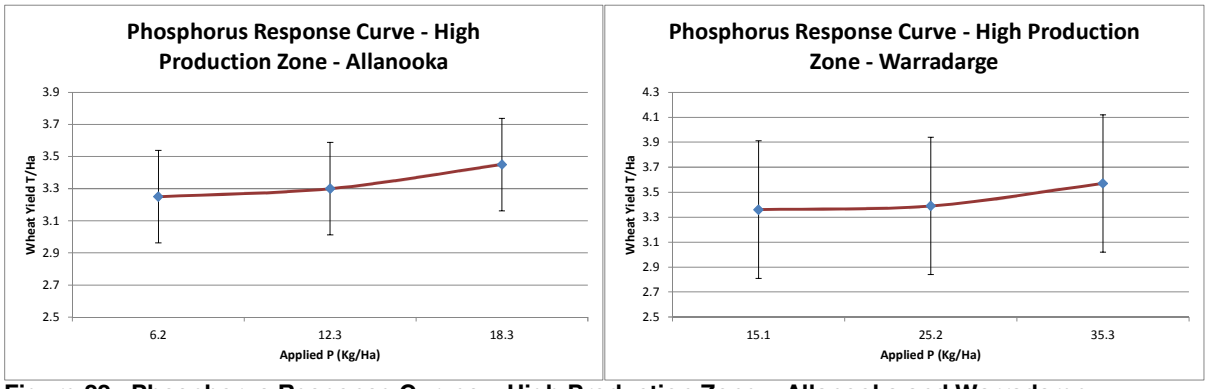


Figure 22. Phosphorus Response Curves – High Production Zone – Allanooka and Warradarge.

Overall, it is clearly evident that the different soil types associated with the varying Production Zones had differing nutrient drivers. Where this variance exists, obviously there exists the opportunity to manipulate nutrition strategies to best manage these key nutrients across the different Production Zones.

The Use of Decision Tools to Enhance the Management of Post Emergent Nutritional Inputs.

An aim of the trial was to utilise Yield Prophet® and soil moisture probes to determine in-season nutrition strategies. As previously detailed, the moisture probes were deleted from many of the sites due to a lack of mobile signal allowing for data transmission and where the moisture probe was installed, data quality was extremely poor and unusable due to repeated vermin damage. The inability to effectively locate moisture probes due to lack of

telecommunication options highlights one weakness of these types of in- field monitoring tools which may limit the uptake in areas suffering poor or unreliable mobile services. Of note, continuous and rapid advances in this technology mean that even now, less than 12 months on from the trial implementation, options utilising non-carrier alternatives are becoming available to overcome these issues.

In the absence of moisture probe data, Yield Prophet® alone was utilised to aid in the determination of in-season nutrition.

Yield Prophet modelled yield potential as compared to actual achieved wheat yield at each site is presented below.

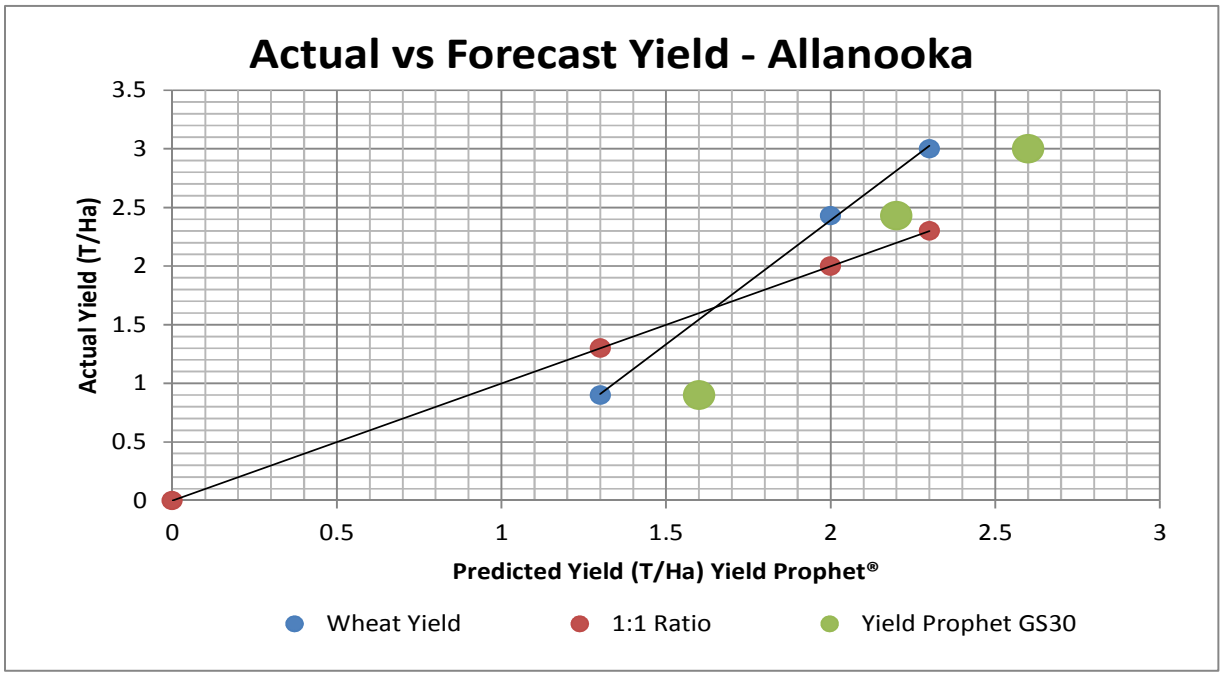


Figure 23. Predicted vs Actual Yield - Allanooka

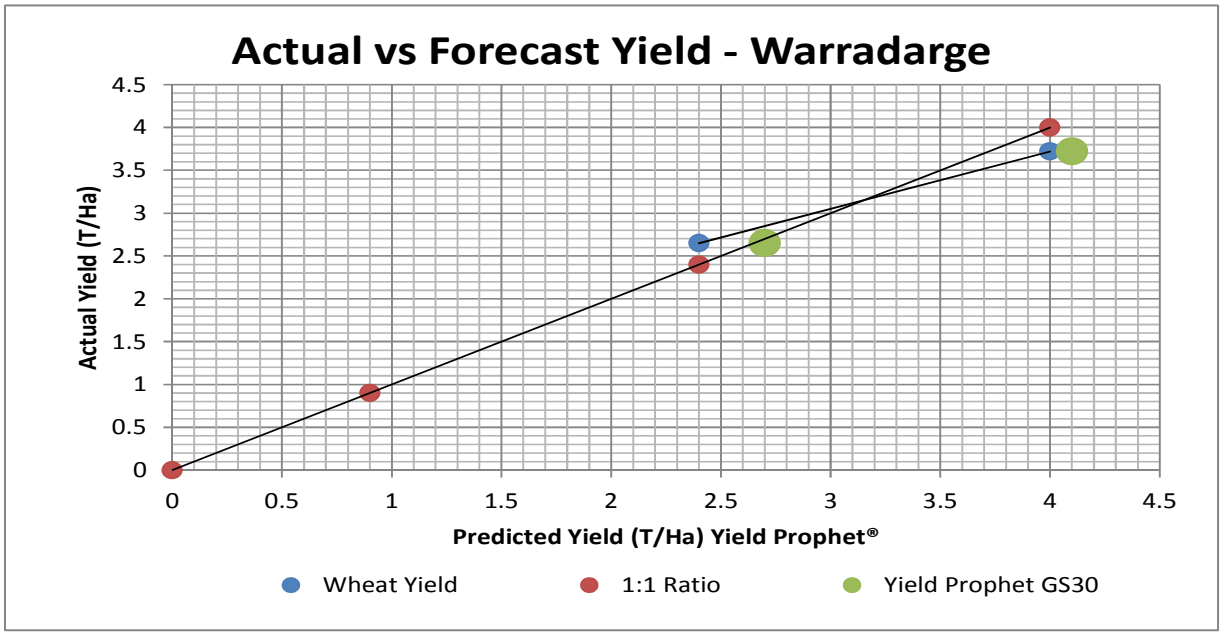


Figure 24. Predicted vs Actual Yield - Warradarge

The relationship between Yield Prophet® predicted yield and actual yield achieved was stronger at Warradarge than Allanooka, despite the tighter finish experienced at that site. Of note though, aside from the Low Production Zone at Allanooka where soil characterisation was potentially slightly incorrect, there was a good relationship between Yield Prophet predicted yield when the model was run immediately prior to the final Nitrogen application at GS30 and final achieved yield. This supports the use of Yield Prophet® as a modelling tool to aid with in-season input decisions.

Implications

This project has generated data generally supportive of the hypothesis that greater return on investment can be achieved through targeted nutrition applications according to soil type, production zone, plant available water (PAW) and seasonal conditions. Frustratingly, however, many results are indicative of trends rather than statistically significant. As with any investment in Nutrition applications, seasonal conditions will dictate the profitability of that investment. This project has demonstrated the positive benefits of targeted nutrition strategies to soil type in a very challenging season.

The project has been able to show that where variation in soil types exists, key nutrient drivers vary and can be managed appropriately. Achievable gross margin associated with management of inputs according to Production Zones has been calculated as high as $50/ha for a best case scenario at the Allanooka trial site. Obviously, this has positive ramifications for VRT implementation and provides supportive evidence of a practice that is becoming increasingly common through the Western Australian Wheat belt.

To achieve maximum benefit from implementation of a VRT strategy, farmers and their advisors must develop a detailed understanding of the variation of their soil nutritional status, key nutrient drivers, use of the latest Soil testing and yield predicting models. Without a sound understanding of the principals involved, inappropriate strategies may result in less favourable outcomes.

Recommendations

Key findings of this project have already been disseminated through field walks and presentations in conjunction with cooperating grower groups. It is suggested that findings are further disseminated through inclusion in GRDC publications, Grower Group Annual Trial Reports and through online portals. Agrarian Management has initiated moves to achieve each of these dissemination processes.

Acknowledgements

Agrarian Management thanks the following people and organisations for their input and collaboration with the project:

Hammersley Fairfield of Allanooka and Falconer Bros. of Warradarge for provision of the sites and contribution of all information relevant to development of the production zones.
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