CORRIGIN FARM IMPROVEMENT GROUP

Using Precision Agriculture to Improve Crop Performance and Grower Returns

Final Report 2006-2007

GRDC Project CFIG2

Using Precision Agriculture to Improve Crop Performance and Grower Returns

Compiled by Garren Knell[1] & Alison Lacey[2]

[1] ConsultAg. Narrogin

[2] Department of Agriculture and Food

The Corrigin Farm Improvement Group (CFIG) wish to thank GRDC for their financial support of this project, and to the following collaborative partners

- James Easton – CSBP
- Ian Maling & Carl Dyde
- Department of Agriculture and Food – John Bruce, Damien Shepherd & Linda Leonard
- Jim Bailey – AirAgronomics

With special thanks to the farmers who donated so much time and resources to the on-farm trials:

W&M Baker, P&A Groves, I, H & S Lee, N&G Turner ,S Wallwork & C Stevens

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PROJECT SUMMARY

Introduction

Many growers in the Corrigin area are adopting guidance systems and VRT capable air seeders. Most growers are just using this technology for auto steering and easy adjustment of seed and fertiliser rates between paddocks.

Aim

To investigating if applying fertiliser according to productivity zones is more profitable than blanket applications of fertiliser across the whole paddock.

We aimed to design trials to demonstrate to growers that matching fertiliser inputs to productivity zones will increase whole paddock profitability compared to blanket applications of fertiliser.

We also aimed to use off the shelf tools (Silverfox/Sky Plan, Nulogic etc) that growers could access to enable them to follow our procedures to adopt VRT across the whole farm.

Methods

The paddocks were zoned using Silverfox's biomass imagery analysis or grower yield maps and grower experience. The analysis incorporated biomass data from 5 seasons of crop performance. This produces a biomass stability map. The biomass stability map identifies zones in the paddock that consistently show poor, average or good performance. This is a useful tool in precision agriculture because it also helps to identify those areas which are unstable in their performance through time.

Target yields for each productivity zone were set using the biomass images and farmer experience.

Soil testing was undertaken in each zone at a depth of 0-10cm and 10-20cm. The Nulogic® crop nutrition model was used to generate the fertiliser requirements to achieve the target yield in each productivity zone.

The sites were tissue tested in August to evaluate nutrient uptake and to ensure that there were no trace element deficiencies that would influence the trial results. The paddocks were also flown by Air Agronomics to assess crop biomass in response to the nutrition treatments.

Trial Designs

The trial was sown with the farmer's air seeder so that a seeding run would pass through each productivity zone. The trials were replicated.

KEY FINDINGS

VRT Performance

Matching fertiliser inputs to productivity zones (VRT) was rarely the most profitable strategy. Table 1 summarises the 9 successful trials undertaken in 2006 and 2007. These were above average production years for the Corrigin area. It is assumed that the low, medium or high fertiliser treatments were blanketed across the whole paddock. The VRT treatment involved apply low inputs to the poor productivity zone, medium inputs to the average productivity zone and high inputs to the good productivity zone.

This summary shows that in 8 of the 9 trials a blanket application of low or medium fertiliser rates was the most profitable way to fertilise the paddocks. High inputs were never the most profitable approach. The VRT approach was only most profitable in 1 of the 9 trials.

The high input treatment was the least profitable strategy in 6 of the 9 trials.

Table 1. Summarises profitability of fertiliser strategies for 9 trials

	Fertiliser Strategy			
	Low	Medium	High	VRT
Most profitable	4	4		1
Least profitable	2		6	1

Phosphate responses

Many of the paddocks where we had our trials were un responsive to phosphate.

Our research has shown that many soils now have sufficient levels of phosphate that crops either don't respond to additional applied phosphate or the responses are very small.

The WA wheat belt has been in a phosphate building phase since clearing. Many farms now have sufficient phosphate levels. Fertiliser regimes could now be reduced to a maintenance regime.

This would offer significant savings to growers especially given that the price of phosphate has tripled in the past two years. There would also be some significant environmental benefits to preventing over fertilising.

Best Fit for VRT

We feel that in the Corrigin area the most economic use of VRT will be for patching out potassium on responsive soil types as well as ameliorating soil with applications of lime or gypsum in the areas which have the highest requirement, rather than blanket applications on areas that do not require amelioration.

VRT could also be used for tactical applications of nitrogen. Where the paddock is blanketed with N and P for and average production season. In an above average season additional nitrogen should be applied to the high productivity zones where the demand for additional nitrogen is likely to be highest.

MATCHING INPUTS TO PRODUCTIVITY ZONES CFIG 2006

W & M Baker

KEY MESSAGES

- The lupins in all productivity zones were unresponsive to applications of phosphate because the soil phosphate levels were adequate.
- Adopting VRT in an unresponsive situation will be un-economical.
- The blanket application of high inputs was the least profitable treatment generating a loss of $2630 across the paddock compared to the blanketing of low inputs.
- A successful lupin crop can be grown with minimal applied phosphate (5 kg/ha) where soil phosphate levels are sound and reactive iron levels are low.

AIMS

To investigate if matching phosphate rates to productivity zone increases whole paddock profitability when sowing lupins.

METHODS

Paddock details

The paddock was sown to Mandelup lupins on 24 May at 80 kg. It was fertilised with 50 kg of legume special (supplying 9.8 kg P and 2 kg of S).

Rotation: Lupins2002/wheat 2003/canola 2004/wheat 2005/lupins 2006.

The site was tissue tested in August to evaluate nutrient uptake and to ensure that there were no trace element deficiencies that would influence the trial results. The paddocks were also flown by Air Agronomics to assess crop biomass in response to the nutrition treatments.

Soil test

Soil testing was undertaken in each zone at a depth of 0-10 cm and 10-20 cm. The Nulogic® crop nutrition model was used to generate the fertiliser requirements to achieve the target yield in each productivity zone.

The phosphate levels ranged from 19-33 ppm across the productivity zones and the paddock had low reactive iron levels (190-370). This indicated that lupins were unlikely to be responsive to additional applied phosphate.

The Nulogic® model was primarily used for determining the requirements of cereal crops. The calibrations in this model are not as robust for lupins. However it indicated that phosphate responses would be unlikely.

The soil tests indicated that there was adequate potassium for a lupin crop (range from 57, 49, 98 ppm), because lupins can exploit the soil for K efficiently. However, K levels were marginal for a cereal crop and responses would have been likely.

The top soil pH ranged from 4.7 to 5.4 and the subsoil pH 4.6 to 4.8. The site was acid and will require liming in the near future to minimise yield losses in barely and canola. However the soil pH did not limit lupin production.

TRIAL DESIGN

This paddock was previously used for VRT trials in 2003 and 2004 (see Final Report 2002-2004). The low, medium and high fertiliser treatments were relocated over the corresponding plots in 2006. This would help to test the impact of fertiliser strategy through time.

The trial had three replications of each treatment running through the poor, average and good productivity zones. Target yields for each productivity zone were set using the biomass images and farmer experience. It was assumed that lupin performance matched that of cereal crops (see below).

Table 1. Fertiliser recommendations to achieve target yield

Productivity zone	Target yield (t/ha)	P rate	Legume Special	Fertiliser cost ($/ha)
Poor (clay)	1	5	30	$13
Average (duplex)	1.5	10	50	$21
Good (gravel)	2	20	100	$42

Economic calculations

2006 list fertiliser prices and a five year average farm gate price for the lupins of $200/t/ha were used for economic calculations.

RESULTS

Grain yield and economics

The lupin performance in this paddock was below average in 2006, with a paddock yield of 0.98 t/ha.

The poor performing zone yielded as expected and was significantly lower yielding than the average and good productivity zones (Table 2). The loamy clay soil type in the poor zone was not an ideal lupin soil mainly as a consequence of transient water logging during winter.

The average and good productivity zones had similar yields with a difference of only 80 kg/ha.

Table 2. Grain yield, quality and price of each fertiliser treatment in poor, average and good productivity zones

	Input	Yield (t/ha)	Price $/t	Gross return ($/ha)
Poor zone	Low	0.71	200	142
	Medium	0.74	200	148
	High	0.7	200	140
	Average	0.72	200	144
Average zone	Low	1.20	200	240
	Medium	1.17	200	234
	High	1.03	200	206
	Average	1.13	200	226
Good zone	Low	1.13	200	226
	Medium	1.10	200	220
	High	1.02	200	204
	Average	1.08	200	216

Response to fertiliser

As predicted the lupins did not provide a yield response to additional phosphate in all three productivity zones. This can be seen in Figure 1 and Table 2.

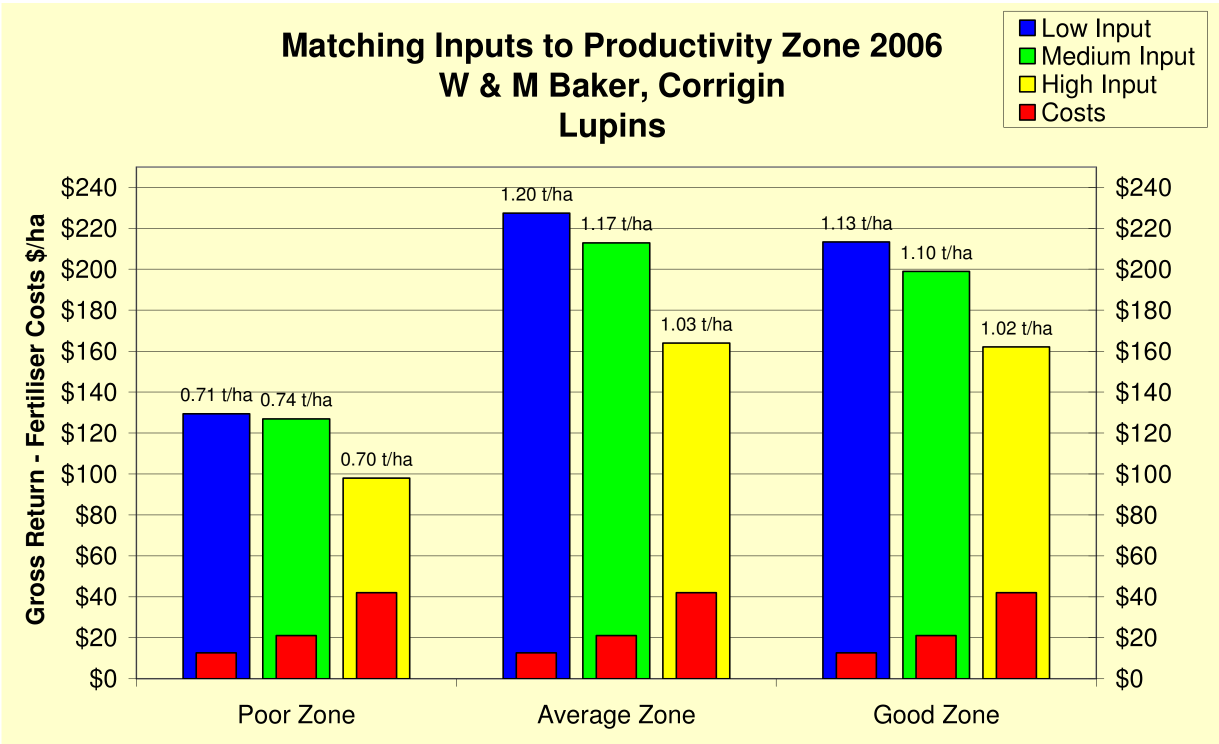

Figure 1. Economics of matching inputs to productivity zones, showing grain yield, fertiliser expenditure and gross return minus fertiliser cost.

As seen in the biomass image (Figure 2) there was very little biomass response to additional fertilisers this means very minimal additional carry over of nitrogen for the following year.

Additional expenditure on fertiliser above the low input treatment resulted in a reduction in income (Figure 1). This result was consistent in all productivity zones. Although expected clearly supports the theory that lupins are less responsive to phosphate than wheat where soil levels are sound.

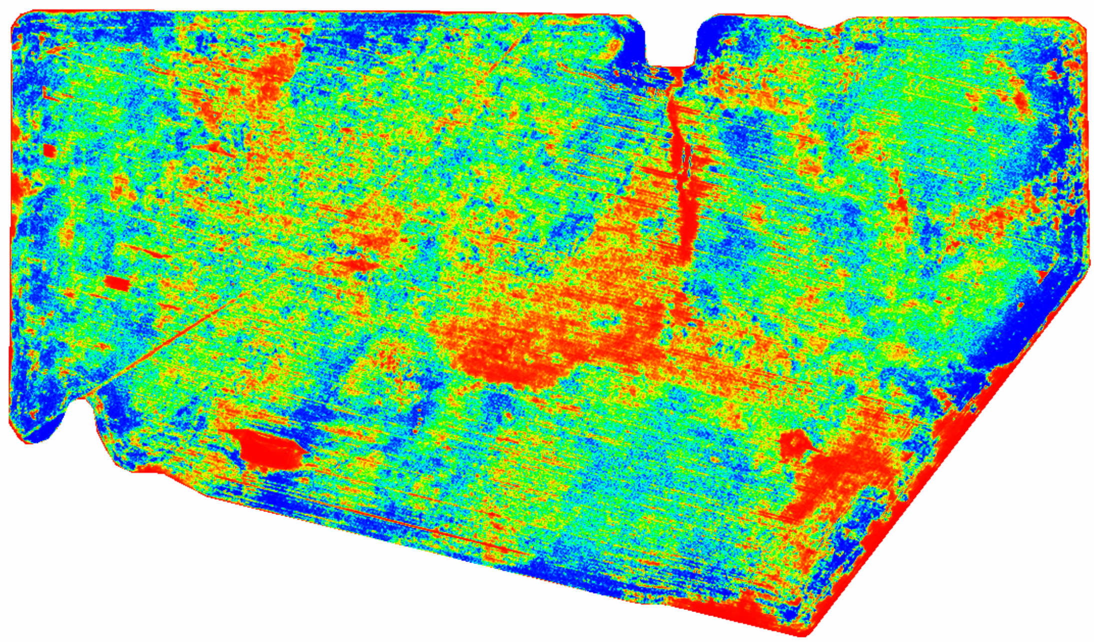

Figure 2. NDVI image showing crop biomass and plot biomass responses to fertiliser treatments.

Zone management vs. blanket application

To calculate the benefit or cost of managing this paddock according to productivity zone we extrapolated the findings across the whole paddock according to the areas of each zone in the paddock (Table 3).

Because there was no response to applied phosphate the blanket application of low fertiliser was the most profitable treatment returning $10,130/ha. The least profitable treatment was the high input treatment returning $2,630 less than the low input treatment.

Adopting VRT and fertilising according to productivity zone would be un-profitable in this situation due to the lack of lupin response to additional phosphate (Table 3).

Table 3. Cost or benefit of matching fertiliser inputs to productivity zones across paddock

	Ha	Low	Medium	High	VRT
Poor	10	1 300	1 270	980	1 300
Average	22	4 995	4 685	3 605	4 685
Good	18	3 835	3 580	2 915	2 915
Paddock gross income	**50**	**10 130**	**9 535**	**7 500**	**8 900**
Difference from low input		**0**	-$595	-$2 630	-$1 230

CONCLUSION

The findings from this trial support previous research that indicates that lupins are less responsive to applied phosphate than cereals where soil phosphate levels are sound.

Adopting VRT in an unresponsive situation will be un-economical.

The blanket application of high inputs was the least profitable treatment generating a loss of $2,630 across the paddock compared to the blanketing of low inputs.

Although the lupin yield in this trial was slightly below average it can still give growers confidence that successful lupin crops can be grown with minimal applications of phosphate where soil phosphate levels are sound and reactive iron levels are low.

This trial was repeated in 2007 on the same plots. This allowed an evaluation of the compounding effects of multiple applications of each treatment (low, medium, high) over repeated years.

MATCHING INPUTS TO PRODUCTIVITY ZONES CFIG 2007

W & M Baker

KEY MESSAGES

- 2007 was a high yielding season with an average yield across the trial of 3.2 t/ha. Because of the high yield only the high input plots had adequate nitrogen supplied to achieve protein above 10 per cent. This resulted in the medium and low input plots being discounted for low protein.
- The most profitable way to fertilise this paddock was to apply a blanket application of medium inputs, this returned $1,150 more than the high input treatment and was significantly less risky for the business as it had an outlay of $68/ha on fertiliser verse $130/ha for the high input treatment.
- If the paddock had been treated with VRT, applying the low inputs on the poor zone, medium inputs on the average zone and high inputs on the good zone there would have been a net loss of $2,400 or 6.7 per cent for the paddock compared to a blanket application of medium inputs.

AIMS

To investigate if matching phosphate rates to productivity zone increases whole paddock profitability when sowing lupins.

To investigate the compounding effect of varying rates of inputs on the same plots in four of the past five seasons.

METHODS

Paddock details

The paddock was sown to Yitpi wheat at 70 kg/ha on 23 May.

The paddock standard fertiliser (outside the trial site) supplied 9.7 kg phosphate, 8.2 kg potassium and 7 kg sulphur and 42 kg nitrogen. The products used were K Gold at 80 kg, 50 kg urea banded at seeding and a further 30 kg Urea top-dressed at first node stage.

Rotation: Lupins 2002/wheat 2003/canola 2004/wheat 2005/lupins 2006/wheat 2007.

The site was tissue tested in August to evaluate nutrient uptake and to ensure that there were no trace element deficiencies that would influence the trial results. The paddocks were also flown by Air Agronomics to assess crop biomass in response to the nutrition treatments.

Soil test

Soil testing was undertaken in each zone at a depth of 0-10 cm and 10-20 cm. The Nulogic® crop nutrition model was used to generate the fertiliser requirements to achieve the target yield in each productivity zone.

The paddock has sound phosphate levels and low reactive iron levels. As a result it was not expected to be highly responsive to phosphate. Nitrogen responses were likely given that this wheat crop was the third cereal crop since a legume.

Table 1. Soil test results

Productivity zone	pH (CaCl)	Organic carbon	Nitrate nitrogen	Ammonium nitrogen	Phosphorus (Colwell)	Reactive iron	Potassium (Colwell)
Poor	5	1.04	25	2	29	391	74
Average	4.7	0.5	23	3	26	223	27
Good	4.8	1.06	14	4	25	232	53

TRIAL DESIGN

This paddock was previously used for VRT trials in 2003, 2004 and 2006. The low, medium and high fertiliser treatments were relocated over the corresponding plots in 2007 (see table 2). This helped to test the compounding effect of fertiliser inputs through time. In 2005 the paddock was treated with a blanket fertiliser application.

The trial had three replications of each treatment running through the poor, average and good productivity zones. Target yields for each productivity zone were set using the biomass images and farmer experience.

Table 2. Fertiliser recommendations to achieve target yield

Fertiliser treatment	Target yield	R rate	N rate	K rate	K Gold rate kg	Urea rate kg	Fertiliser cost $/ha
Low	2 t	4	7	3.5	33	15	$23
Medium	3 t	8	40	6.7	66	77	$68
High	4 t	14	80	11.8	116	157	$130

Economic calculations

Financial calculations used 2007 list fertiliser prices. The grain prices were calculated individually for each treatment using the January 2008 AWB golden rewards premiums and discounts. The prices used were a rolling 5 year average Fob price. This was chosen to minimise the massive fluctuations in wheat price over the life of the project.

RESULTS

Grain yield and economics

2007 was a high yielding season with an average yield across the trial of 3.2 t/ha. Because of the high yield only the high input plots had adequate nitrogen supplied to achieve protein above 10 per cent. The medium and low input plots were discounted for low protein.

Zone performance

The good productivity zone as expected had the highest yield in the paddock with an average yield across treatments of 3.44 t/ha. The poor and average zones yielded significantly lower than the good zone and had similar yields 3.12 and 3.18 t/ha respectively. The low productivity zone in this paddock is a loamy clay moisture gaining site which often gets water logged. The 2007 winter was quite dry at this site so there was minimal water logging. This enabled the usually poor performing zone to have a higher yield than average.

Response to fertiliser

Across all productivity zones there was a yield response to increasing fertiliser supply (Table 3 and Figure 2). The low input treatment (4 kg P, 7 kg N and 3.5 kg K) across all zones was the lowest yielding treatment with an average yield of 2.8 t/ha. It also had the lowest gross return in all sites (Figure 2). There was very little difference between the yield and gross returns for the medium and high input treatments with an average yield of 3.4 t/ha and 3.47 t/ha for the medium and high input respectively (Figure 2). The high input treatment (14 kg P and 80 kg N) was less profitable than the medium (8 kg P and 40 kg N) input as it achieved similar yields at a higher cost.

Table 3. Grain yield, quality and price of each fertiliser treatment across productivity zones

	Input	Yield (t/ha)	Hect wt	Screenings (%)	Protein (%)	Pay grade	Price ($/t)	Gross return
Poor zone	Low	2.63	79.6	7.4	8.6	APW	235	$620
	Medium	3.28	80.0	6.5	8.9	APW	239	$785
	High	3.47	80.8	4.5	10.4	APW	251	$870
Average zone	Low	2.78	82.7	4.8	8.9	APW	244	$680
	Medium	3.33	82.2	4.3	9.2	APW	245	$816
	High	3.43	81.3	2.7	10.0	APW	255	$876
Good zone	Low	3.21	80.1	4.4	8.8	APW	241	$777
	Medium	3.6	80.2	3.5	9.8	APW	249	$896
	High	3.51	80.3	3.7	11.2	APW	255	$898

The biomass image (figure 1) shows that the crop biomass reflects the paddock zoning with the most crop biomass in the good zones (blue colour) and the lowest biomass (red colour) in the poor productivity zones. It was also easy to identify the low input plots as they had significantly less crop biomass, especially in the good productivity zone.

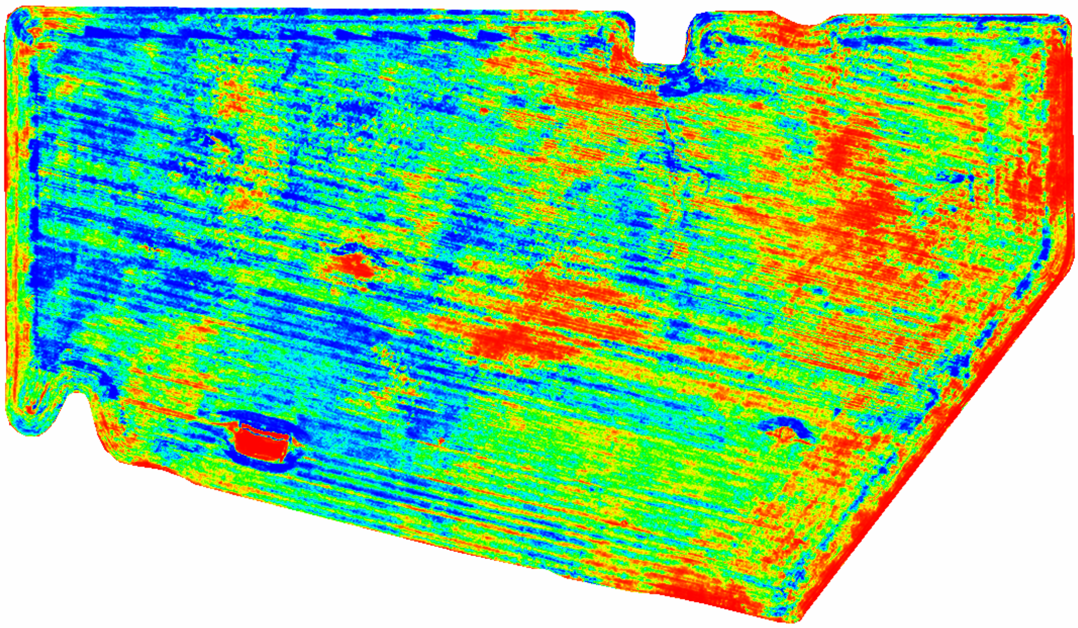

Figure 1. NDVI image showing crop biomass and plot biomass responses to fertiliser treatments.

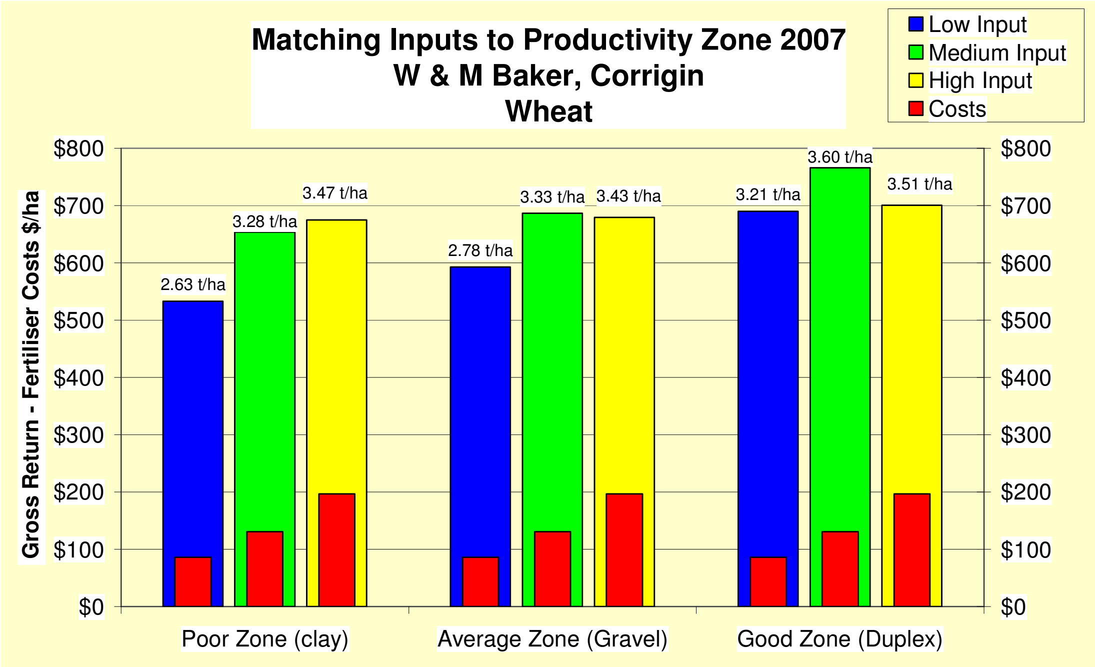

Figure 2. Economics of matching inputs to productivity zones, showing grain yield, fertiliser expenditure and gross return minus fertiliser cost.

Figure 3: Stripping visible in paddock August 2007

Zone management vs. blanket application

The most profitable way to fertilise this paddock was to apply a blanket application of medium inputs (Table 3), this returned $1,150 more than the high input treatment and was significantly less risky for the business as it had an outlay of $68/ha on fertiliser verse $130/ha for the high input treatment.

If the paddock had been treated with VRT, applying the low inputs on the poor zone, medium inputs on the average zone and high inputs on the good zone there would have been a net loss of $2,400 or 6.7 per cent for the paddock compared to a blanket application of medium inputs.

The blanket low input treatment was the lowest returning option, returning $4,650 less than the medium input. This result is not surprising given that the average plot yield was 3.2 t/ha. With the high yielding season the low inputs did not supply adequate nutrients to optimise grain yield.

The low input plots have received low fertiliser treatments in four of the past five seasons. Given that the fertiliser inputs have been lower than the fertiliser removed in the grain we may have limited the ability of the soil to supply the additional nutrients to the crop in an above average season like 2007.

Table 3. Cost or benefit of matching fertiliser inputs to productivity zones

	Ha	Low	Medium	High	VRT
Poor	10	5 333	6 537	6 748	5 333
Average	22	13 046	15 103	14 944	15 103
Good	18	12 420	13 793	12 612	12 612
Paddock gross income	**50**	**30 800**	**35 450**	**34 300**	**33 050**
Difference from medium input		**-$4 650**	**0**	**-$1 150**	**-$2 400**

CONCLUSION

At this trial site in 2007 and in previous seasons there has been a poor economic return from using VRT technology to fertilise crops. In most situations blanket applications of either medium or low inputs have been the most profitable way to fertilise the paddock.

The high input treatments rarely give large enough yield responses to cover the additional cost of the fertiliser, even in the high productive zones.

Our research shows that farmers should fertilise for the average season on paddocks with sound phosphate levels (above 25 ppm) and low phosphate binding. In favourable seasons where the yield potential is high the soil has the ability to supply the additional nutrients.

MATCHING INPUTS TO PRODUCTIVITY ZONES CFIG 2006

P & A Groves

KEY MESSAGES

- Blanket applications of medium inputs (5 kg P and 15 kg N) were the most profitable method of fertilising the paddock, compared too high and low inputs.
- If VRT fertiliser program (high inputs to the best area of the paddock and low inputs to the poor area) had been applied to the paddock it would have returned $4500 less than the blanket treatment of medium inputs.
- The nil fertiliser treatment was the second most profitable treatment, returning only $1200 less than the medium input treatment. This result should give comfort to growers to know that they can reduce fertiliser inputs in the short term on soils with sound P levels and low reactive irons with minimal impact on yield. The site yields ranged from 2.5-3 t/ha.

AIMS

To better match fertiliser inputs to productivity zones to increase whole paddock profitability.

METHODS

Paddock details

The paddock was sown to lupins in 2005 and Calingiri wheat in 2006.

Calingiri wheat was sown at 80kg on the 28 May 2006.

The sites were tissue tested in August to evaluate nutrient uptake and to ensure that there were no trace element deficiencies that would influence the trial results. The paddocks were also flown by Air Agronomics to assess crop biomass in response to the nutrition treatments.

Soil Test

Soil testing was undertaken in each zone at a depth of 0-10 cm and 10-20 cm. The Nulogic® crop nutrition model was used to generate the fertiliser requirements to achieve the target yield in each productivity zone.

Soil tests indicated that the site had high phosphate levels and low to ideal reactive iron levels (See Table 1). This means that the site was unlikely to be very responsive to phosphate. The soil nitrogen levels were not high. This was surprising considering the previous legume crop and mineralisation from summer rain. There may have been some leaching of nitrate from the soil surface.

Table 1. Soil test results

Productivity zone	pH (CaCl)	Organic carbon	Nitrate nitrogen	Ammonium nitrogen	Phosphorus (Colwell)	Reactive iron	Potassium (Colwell)
Poor	4.9	0.74	36	5	31	326	87
Good	4.6	0.4	11	1	27	451	87

Note: Sub soil data not included.

Table 2 shows the target yield for each productivity zone and the recommended rate of nitrogen and phosphate to achieve the target yield. The soil tests indicated that there was no additional phosphate or nitrogen required to achieve the 2 t target yield in the low zone.

Table 2. Fertiliser recommendations to achieve target yield

Fertiliser treatment	Target yield t/ha	Phosphate kg/ha	Nitrogen kg/ha	Cost $/ha
Low	2	0	0	0
Medium	3	5	15	$30
High	4	10	55	$91

TRIAL DESIGN

The trial was sown with the farmer's air seeder so that a seeding run would pass through each productivity zone. The plots were two air seeder widths wide and two yield measurements were harvested from each plot. This gave four replications. Plot lengths were a minimum of 100 m in each zone.

Economic calculations

All financial calculations used 2006 list fertiliser prices. The grain prices were calculated individually for each treatment using the December 2006 AWB golden rewards premiums and discounts. The prices were then converted back to a farm gate price. The calculated returns for each treatment represent gross income minus fertiliser and application cost.

RESULTS

The paddock received around (198 mm) of rain during January, February and March of which 150 fell in January. It was a dry winter and short spring and the crop received approximately (148 mm) of growing season rainfall.

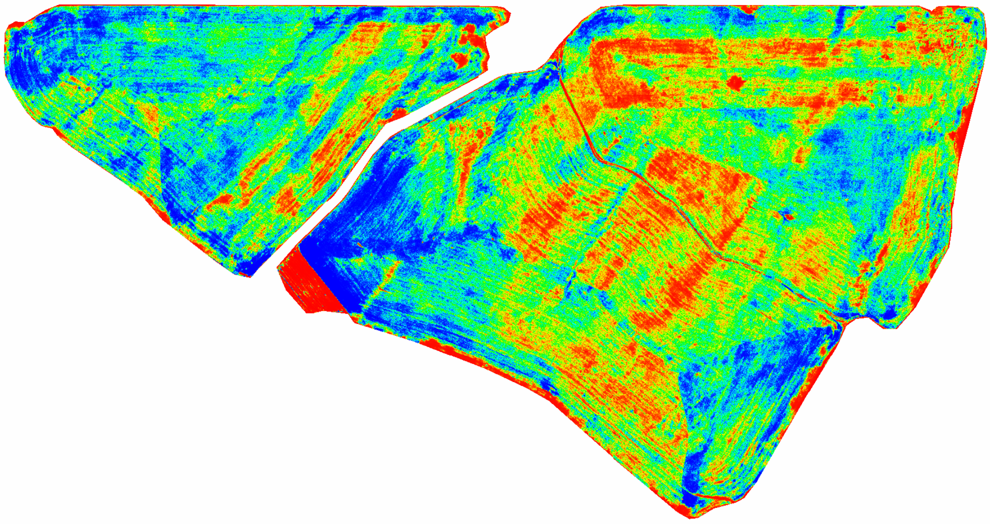

Figure 1. NDVI image of crop biomass.

Grain yield and economics

The paddock was high yielding, especially given the dry season, however the zones did not perform as predicted. The poor performing zone was the highest yielding with an average yield of 3.06 t/ha (Table 3, Figure 2). It is not clear why this occurred and will require further investigation. The average production zone achieved the lowest yield (2.6 t/ha) and the good zone achieved the median yield (2.87 t/ha).

Table 3. Grain yield, quality and price of each fertiliser treatment across productivity zones

	Input	Yield (t/ha)	Hect wt	Screenings (%)	Protein (%)	Moisture (%)	Pay grade	Price ($/t)
Poor zone	Low	2.93	80.9	2.4	10.2	10.1	ASWN	$215
	Medium	3.19	81.2	2.1	10.1	10.1	ASWN	$215
	High	3.07	78.0	5.0	11.9	10.1	ASW	$197
Average zone	Low	2.48	80.6	2.7	11.0	10.3	ASWN	$212
	Medium	2.62	80.6	2.9	11.4	10.2	ASWN	$210
	High	2.71	79.0	3.8	12.2	10.2	ASW	$200
Good zone	Low	2.66	81.2	2.4	10.4	10.3	ASWN	$215
	Medium	3.01	81.1	2.1	10.4	10.2	ASWN	$216
	High	2.94	78.1	4.5	11.8	10.2	ASW	$197

Across all zones the medium input treatment achieved the greatest returns except in the average zone where it had equivalent returns to the low input treatment (Figure 2). The low and medium input treatments were able to achieve ASWN quality in all zones; however the high input treatment was discounted to ASW due to high protein. This is not surprising given the high nitrogen supply and sharp finish to the season. If a AH or APW variety had been grown the high input treatments would have received a protein premium rather than a discount and would have increased the returns. The grain yield failed to respond to the additional nitrogen and phosphate applied in the high input treatments and in most cases it suffered a yield penalty as well as grain quality discounts (Table 3).

The low input treatment exceeded the target yield (2 t/ha) in all productivity zones (average yield 2.69 t/ha). This is an exceptional yield to achieve across all 3 zones given there was no applied fertiliser.

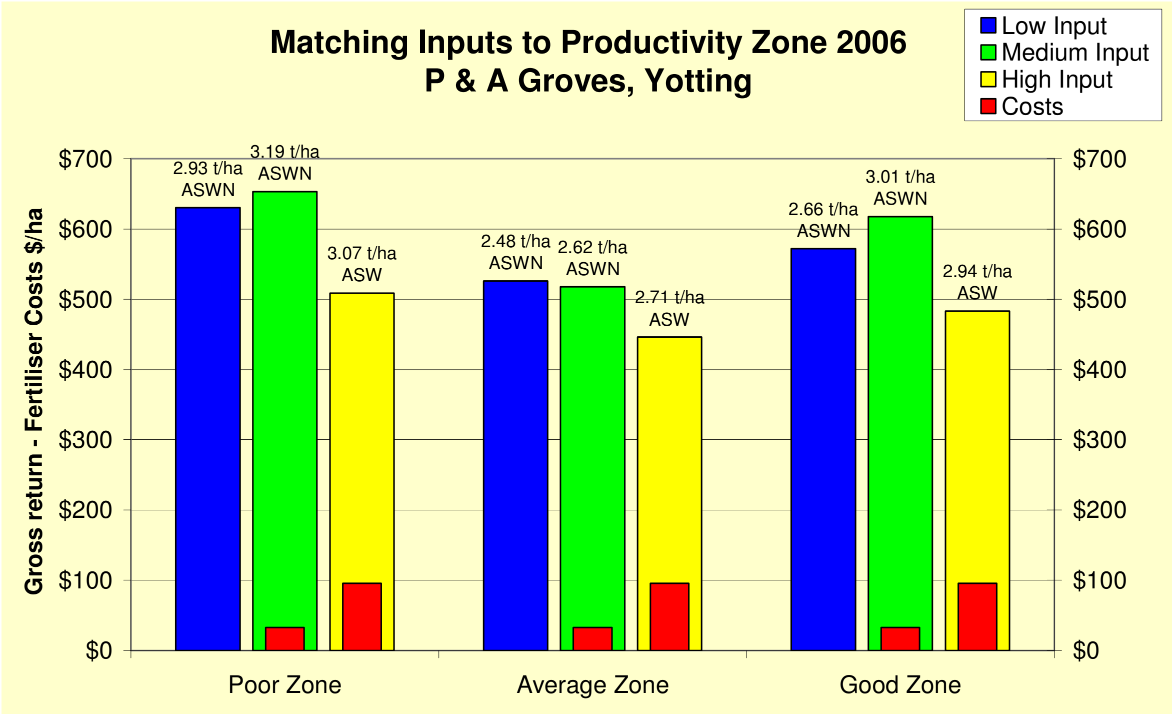

Figure 2. Economics of matching inputs to productivity zone.

Note: no costs associated with low input as no fertiliser used.

Zone management vs. blanket treatment

To calculate the benefit or cost of managing this paddock according to productivity zones we extrapolated the findings across the whole paddock according to the area of each zone in the paddock (Table 4).

If the paddock was sown using VRT and nutrition was applied according to predicted zone performance there would have been a net loss of $4,494 (8%) in this 105 ha paddock compared to a blanked application of the medium input (Table 4).

The most profitable management option for this paddock would have been a blanket application of medium inputs (fertiliser cost $30/ha). The blanked application of low input treatment (nil fertiliser) generated the next best returns which were only $1,186 less or a 2 per cent reduction in income for nil fertiliser expenditure. This is a surprising result and it is pleasing to know that fertiliser inputs can be reduced (in the short term) without significantly compromising yield where soil nutrition levels are high (N, P, K, S) and reactive iron levels are low.

Results would have been different if there had been a better finish to the season; however the site still achieved above the 5 and 10 year average yield for the district.

Table 4. Cost or benefit of matching fertiliser inputs to productivity zones

	Ha	Low	Medium	High	VRT
Poor	10.5	6 615	6 857	5 345	6 615
Average	63.0	33 138	32 634	28 098	32 634
Good	31.5	18 018	19 467	15 215	15 215
Paddock gross income	**105**	**57 771**	**58 958**	**48 657**	**54 464**
Difference from medium input		**-$1 186**	**$0**	**-$10 300**	**-$4 494**

CONCLUSION

Blanket applications of medium inputs (5 kg P and 15 kg N) were the most profitable way to fertilise the paddock. Unfortunately if the paddock had been fertilised with VRT applying the high inputs to the best area of the paddock and the low inputs to the poor area of the paddock it would have returned $4,500 less than the blanket treatment of medium inputs.

This trial generated some very interesting data and showed that the soil phosphate bank can be drawn upon to supply a crops phosphate requirement where the soil phosphate levels are sound and the phosphate retention is low.

While we would not advocate wide scale sowing of crops with nil phosphate fertiliser, this data gives growers confidence to reduce rates in difficult times (when soil testing is undertaken) and know that the yield penalty will be low even in good producing seasons.

This trial was replicated in 2007 (see next page) to investigate the compounding effect of low fertiliser inputs over two seasons.

MATCHING INPUTS TO PRODUCTIVITY ZONES CFIG 2007

P & A Groves

KEY MESSAGES

- In soils with high P levels and low reactive iron levels there is scope for growers to reduce P rates with no loss in yield over a 2-3 year period.
- Two wheat crops in 2006 and 2007 achieved over 2 t yields with no applied phosphate. In most cases the slight reduction in yield was not severe enough to limit profitability, with the nil treatment being the most profitable treatment in one zone and the second most profitable treatment across the whole paddock.
- The most profitable treatment in the paddock was a blanket application of medium input (returning $51 200), the VRT treatment was second ($48 800) and the blanket low input treatment (nil P) was third ($48 400). The poorest performing treatment was the blanket application of high inputs ($41 900).

AIMS

To better match fertiliser inputs to productivity zones to increase whole paddock profitability.

To investigate the compounding effect of varying rates of inputs on the same plots two years in a row.

METHODS

The paddock was zoned in 2006 using Silverfox's biomass imagery analysis (see 2006 report for more detailed description of zoning methodology). Target yields for each productivity zone were set using the biomass images and farmer experience (Table 2). 2007 was a repeat of the 2006 trial with updated fertiliser inputs in response to soil tests and target yields. Each treatment was repeated on the same plot in both years (e.g. Low on Low).

Paddock details

The paddock was sown to lupins in 2005 and Calingiri wheat in 2006. The paddock was sown to Calingiri on 27 May at 80kg/ha.

Rotation: Lupins 05/Calingiri Wheat 06/Calingiri Wheat 07.

The standard paddock fertiliser (outside the trial area) was Agstar Extra and FlexiN at sowing and Top up FlexiN post emergent.

Soil test

The plots were re-soil tested in 2007 and treatments were repeated over the 2006 plots. Soil tests indicated that the site had high phosphate levels and low to ideal reactive iron levels (Table 1). This means that the site was unlikely to be very responsive to phosphate. The soil nitrogen levels were not high.

Table 1. Soil test results

Productivity zone	pH (CaCl)	Organic carbon	Nitrate nitrogen	Ammonium nitrogen	Phosphorus (Colwell)	Reactive iron	Potassium (Colwell)
Poor	4.9	0.74	36	5	31	326	87
Good	4.6	0.4	11	1	27	451	87

The Nulogic® crop nutrition model was used to generate the fertiliser requirements to achieve the target yield in each zone. Target yields were reviewed post emergence according to time of sowing and rainfall. The crop was sown later than planned into marginal moisture (27 May) so target yields were revised down by 500 kg at each site. Nitrogen levels were adjusted to reflect the new target yields (Table 2).

The soil tests indicated that there was no additional phosphate required to achieve the 1.5 t target yield in the low zone.

Table 2. Fertiliser recommendations to achieve target yield

Fertiliser treatment	Target yield t/ha	Phosphate kg/ha	Nitrogen kg/ha	Cost $/ha
Low	1.5	0	19	$22
Medium	2.5	5	36	$55
High	3.5	10	74	$112

TRIAL DESIGN

See previous report for 2006 for trial design

The sites were tissue tested to evaluate nutrient uptake and ensure that there were no trace element deficiencies that would influence the trial results. The paddocks were also flown by Air Agronomics to assess crop biomass in response to the nutrition treatments.

Economic calculations

Financial calculations used 2007 list fertiliser prices. The grain prices were calculated individually for each treatment using the January 2008 AWB golden rewards premiums and discounts. The prices used were a rolling 5 year average Fob (gate) price. This was chosen to minimise the massive fluctuations in wheat price over the life of the project.

RESULTS

Grain yield and economics

All three zones had surprisingly similar yields. The poor performing zone yielded 2.24 t/ha, the average zone yielded 2.15 t/ha and the good zone yielded 2.29 t/ha (Table 3, Figure 2). The site was severely water stressed in early spring however late rains enabled good grain fill. We feel that the spring moisture stress limited yield potential of most treatments. However the overall yield was average to above average.

Once again the area identified through the biomass imagery as poor performing was the highest yielding zone in the paddock. This highlights the importance of using actual yield in combination with biomass to identify productivity zones.

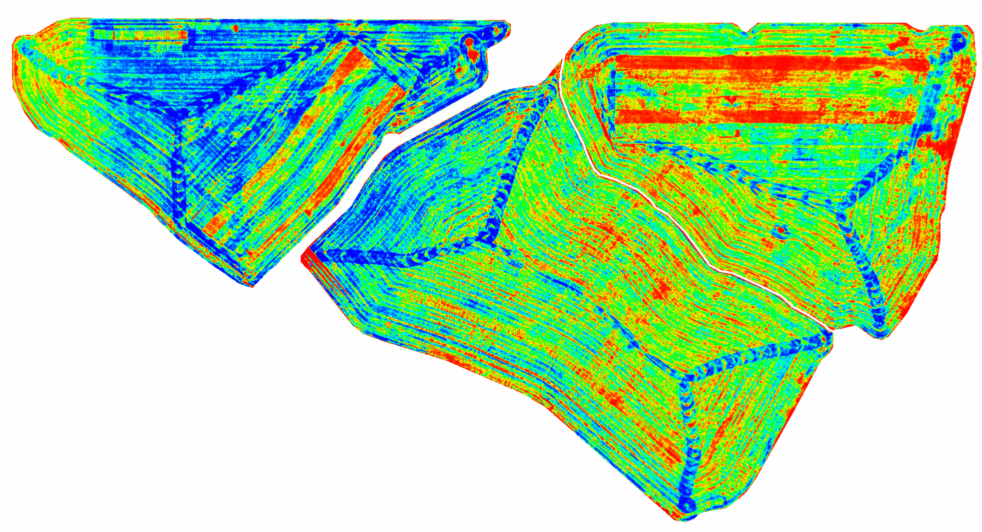

Figure 1. NDVI image of crop biomass.

Across all zones the medium input treatment achieved the greatest returns except in the poor zone where it had equivalent returns to the low input treatment (Figure 2). The low and medium input treatments were able to achieve ASWN quality in most zones, however the high input treatment was discounted to ASW due to high protein at all sites. This is not surprising given the high nitrogen supply and moisture limited yield.

Table 3. Grain yield, quality and price of each fertiliser treatment across productivity zones

	Input	Yield (t/ha)	Hect wt	Screenings (%)	Protein (%)	Moisture (%)	Pay grade	Price ($/t)
Poor zone	Low	2.22	82.3	2.2	10.0	10.4	ASWN	$263
	Medium	2.29	82.2	1.61	10.7	10.3	ASWN	$265
	High	2.20	79.5	1.60	13.9	10.3	ASW	$261
Average zone	Low	2.03	82.4	1.97	10.8	10.4	ASWN	$265
	Medium	2.28	82.6	1.5	11.6	10.4	ASW	$259
	High	2.15	81.5	1.7	13.6	10.4	ASW	$261
Good zone	Low	2.10	81.8	1.7	10.2	10.7	ASWN	$265
	Medium	2.40	81.3	1.7	10.6	10.3	ASWN	$265
	High	2.37	80.8	1.5	13.0	10.7	ASW	$261

Comparisons using an APW variety increased returns slightly on the high input treatments, but not enough to change the treatment rankings (data not shown). The grain yield failed to respond to the additional nitrogen and phosphate applied in the high input treatments and in most cases it suffered a yield penalty as well as grain quality discounts (Table 3).

The low input treatment exceeded the target yield (1.5 t/ha) in all productivity zones (average yield 2.12 t/ha). This is an exceptional yield to achieve across all three zones given there was no phosphate applied to these treatments in 2006 and 2007.

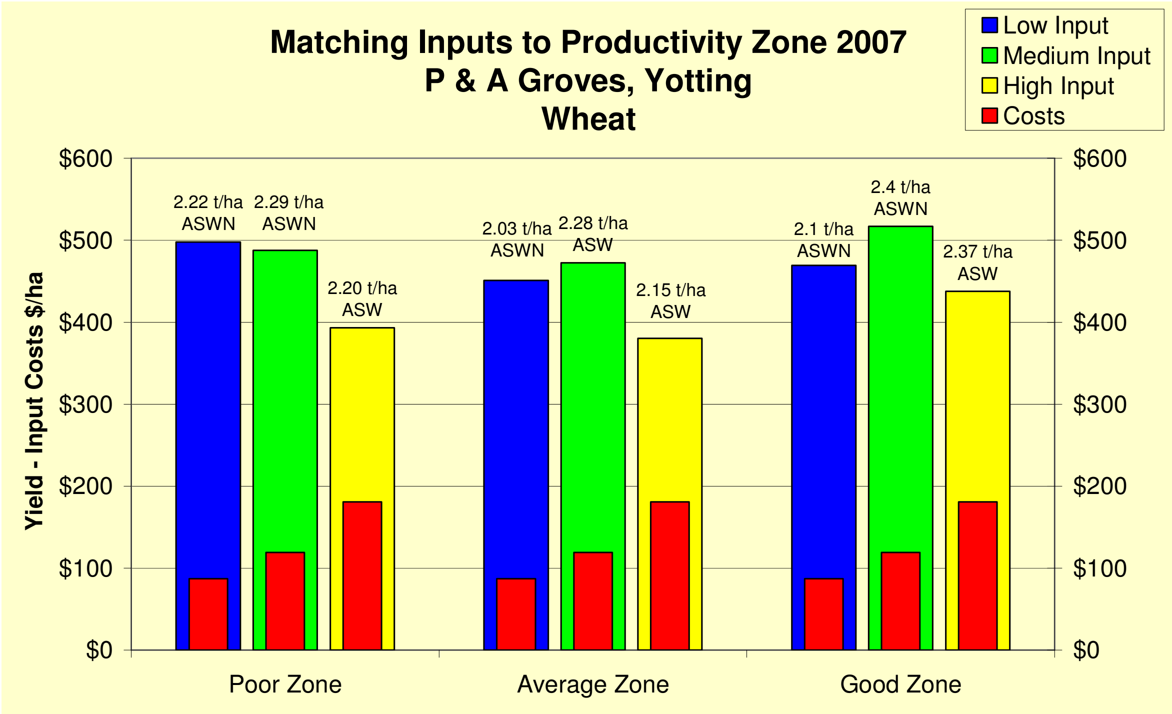

Figure 2. Economics of matching inputs to productivity zones.

Figure 3. Stripping visible in poor production zone July 2007

Zone management vs. blanket treatment

If the paddock was sown using VRT and nutrition was applied according to predicted zone performance there would have been a net loss of $2,400 (5%) in this 105 ha paddock compared to a blanked application of the medium input (Table 4).

The most profitable management option for this paddock would have been a blanket application of medium input (fertiliser cost $55/ha). The blanket application of low input treatment (nil P, 19 kg N) generated the next best returns which were only $2,800 less than the most profitable treatment. This is a surprising result and it is pleasing to know that fertiliser inputs can be reduced (in the short term) without significantly compromising yield where soil nutrition levels are high (N, P, K, S) and reactive iron levels are low. Blanket applications of high input treatments returned $9,300 less than medium inputs.

Table 3. Cost or benefit of matching fertiliser inputs to productivity zones

	Ha	Low	Medium	High	VRT
Poor	10.5	5,200	5,100	4,100	5,200
Average	63.0	28,400	29,800	24,000	29,800
Good	31.5	14,800	16,300	13,800	13,800
Paddock gross income	**105**	**$48,400**	**$51,200**	**$41,900**	**$48,800**
Difference from medium input		**- $2 800**	**$0**	**-$9 300**	**-$2 400**

CONCLUSION

This trial site has generated a great deal of exciting information over the two trial years.

In soils with high P levels and low reactive iron levels there is scope for growers to reduce P rates with no loss in yield over a 1-2 year period.

Two wheat crops in a row achieved over 2 t yields with no applied phosphate. In most cases the slight reduction in yield was not severe enough to limit profitability, with the nil treatment being the most profitable treatment in one zone and the second most profitable treatment across the whole paddock.

The most profitable treatment in the paddock was a blanket application of medium input (returning $51,200), the VRT treatment was second ($48,800) and the blanket low input treatment (nil P) was third ($48,400). The poorest performing treatment was the blanket application of high inputs ($41,900).

An area for future research could focus on optimum soil phosphate levels for a given soil phosphate retention. This means growers could draw on the soil phosphate bank in difficult times by only applying maintenance rates of phosphate.

WA soils are naturally phosphate deficient. Since clearing, growers have been applying phosphate to crops and pastures to maintain growth and build up soil levels. Our trial results indicate that in some situations the soil phosphate levels are now at high levels and growers can look at fertilising to maintain phosphate levels rather than building up soil levels.

MATCHING INPUTS TO PRODUCTIVITY ZONES CFIG 2006

I & H Lee

KEY MESSAGES

- There were no key findings from this trial due to errors in the trial lay out.

AIMS

To investigate if matching fertiliser inputs to productivity zones increases whole paddock returns.

To demonstrate if variable rate technology or applying inputs according to productivity zones is likely to increase returns compared to managing the paddock as one unit.

To test the compounding effect of previous fertiliser treatments from 2003 and 2004

METHODS

Investigations were then undertaken to identify factors that may be limiting production in each zone.

Paddock details

Rotation: Canola 01/Wheat 02/Lupins 03/Wheat 04/Canola 05/Wheat 06

The paddock was sown to 2248 Soft Wheat sown on the 3 June 2006 at 70 kg/ha.

The paddock standard fertiliser (outside the trial) used was 30 kg MOP pre seeding
100 kg Agrich + 40 L FlexiN banded.

In 2005 the paddock was sown to canola with blanket fertiliser treatments.

Soil tests

Soil tests indicated that this site would be responsive to phosphate, Nitrogen and Potassium.

The paddock was treated with a basal application of 30kg MOP (15kg K) spread in autumn.

Table 1. Soil test results

Productivity zone		pH (CaCl)	Organic carbon	Nitrate nitrogen	Ammonium nitrogen	Phosphorus (Colwell)	Reactive iron	Potassium (Colwell)
Poor	Top	5.5	0.53	22	2	14	110	40
	Sub	5.6	0.36	5	1	18	101	22
Average	Top	4.9	0.61	20	3	10	88	29
	Sub	4.7	0.44	6	1	13	111	34
Good	Top	4.9	1	17	1	19	293	67
	Sub	4.4	0.69	4	1	26	358	107

TRIAL DESIGN

The paddock was sown up and back with each treatment crossing the high medium and low productivity zones. Each treatment was 4 air seeder widths wide and 2 boom widths wide to allow a large treatment area so that responses could be measured using biomass imagery as well as with the header.

There were 2 replications of each treatment; however plots were sub-sampled to allow four data points for each treatment to aid statistical analysis.

The plots were to be overlaid over the same treatments that were used in 2003 and 2004. For example low, medium and high input back on low, medium and high plots, so that the crop could respond to the compounding effects of the previous fertiliser regime.

Table 2. Fertiliser recommendations to achieve target yield

Fertiliser treatment	Target yield t/ha	Phosphate kg/ha	Nitrogen kg/ha
Low	1 t	5	4
Medium	2.5 t	12	45
High	4 t	18	100

Table 3. Revised fertiliser recommendations to achieve target yield

Fertiliser treatment	Target yield t/ha	Phosphate kg/ha	Nitrogen kg/ha	Cost $/ha
Low	1	5	4	$22
Medium	2	12	33	$80
High	3	18	72	$146

RESULTS

Unfortunately there was an error with this trial at seeding time.

Instead of each treatment plot being sown 4 air seeder widths wide, it was only sown 2 air seeder widths wide. This resulted in a concertina effect of the trial and the treatments were not overlaid over the same treatments in previous years (2003 and 2004).

This has made the trial invalid and it is not possible to draw any strong conclusions from the data produced because the residual fertiliser from the previous treatments will have influenced the response to the 2006 treatments. However average treatment yields and quality results have been included for the average and good production zones (see table 4)

Table 4. Treatment averages for average and good productivity zone

Average production zone				
	Yield (t/ha)	Hect wt	Screenings (%)	Protein (%)
Low	3.32	80.2	2.6	8.9
Medium	3.63	80.4	2.4	9.3
High	3.81	80.2	3.9	9.8
Good production zone				
Low	2.97	81	2.7	8.8
Medium	2.81	79	5.3	9.2
High	2.99	76	10.9	10.4

CONCLUSION

No strong conclusions can be drawn from this trial due to errors in the seeding layout.

MATCHING INPUTS TO PRODUCTIVITY ZONES CFIG 2007

I & H Lee

KEY MESSAGES

- To get VRT to be effective paddock zone performance needs to be predictable or repeatable through time.
- The most profitable way to fertilise this paddock was to apply a blanket application of 20 kg nitrogen per hectare.
- This paddock was unresponsive to phosphate (soil tests > 40 ppm) and did not require any additional phosphate to optimise returns. It highlights the benefits of knowing a soils phosphate status when planning a fertiliser regime

AIMS

To better match fertiliser inputs to productivity zones to increase whole paddock profitability.

To test our procedures and systems for evaluating the benefits of variable rate fertilising on a new paddock that we had not previously worked with.

METHODS

Paddock details

This paddock was recently purchased and the farmer was growing his first crop on it. Under the previous management the paddock was in a pasture/wheat rotation. The pasture was grass dominant with very little clover.

The paddock was sown to the soft wheat variety 2248 on 16 June. This was later than ideal due to the late break to the season. Target yields were amended to reflect the change in yield potential.

The paddock was zoned using Silverfox's biomass imagery analysis. The analysis incorporated biomass data from 5 seasons of crop performance. This produced a biomass stability map (Figure 1). The biomass stability map identifies zones in the paddock that consistently show poor, average or good performance. This is a useful tool in precision agriculture because it also helps to identify those areas which are unstable in their performance through time.

We chose to run the nutrient treatments through the high stable productivity zone (Dark Blue) and the High Unstable zone (light Blue) and the poor productivity zone (Pink and Red).

The high productivity zone was made up of York Gum/Jam soil which has good moisture holding capacity and high yield potential. The high unstable zone is an area of Grey clay/loam located high in the landscape. In some season this soil could become waterlogged and limit crop yield, other seasons production can be high.

The low productivity zone is a low lying grey clay soil which will become waterlogged and un-trafficable most seasons. With early sowing and good management this zones productivity could be improved significantly.

Each plot was 29.2m wide, made up of two passes of the air seeder. At harvest we weighed two header cuts taken from each plot. There were 2 replications but 4 sample points for each treatment.

All the nitrogen was applied in the form of Flexi N at sowing or post emergent with the boom spray.

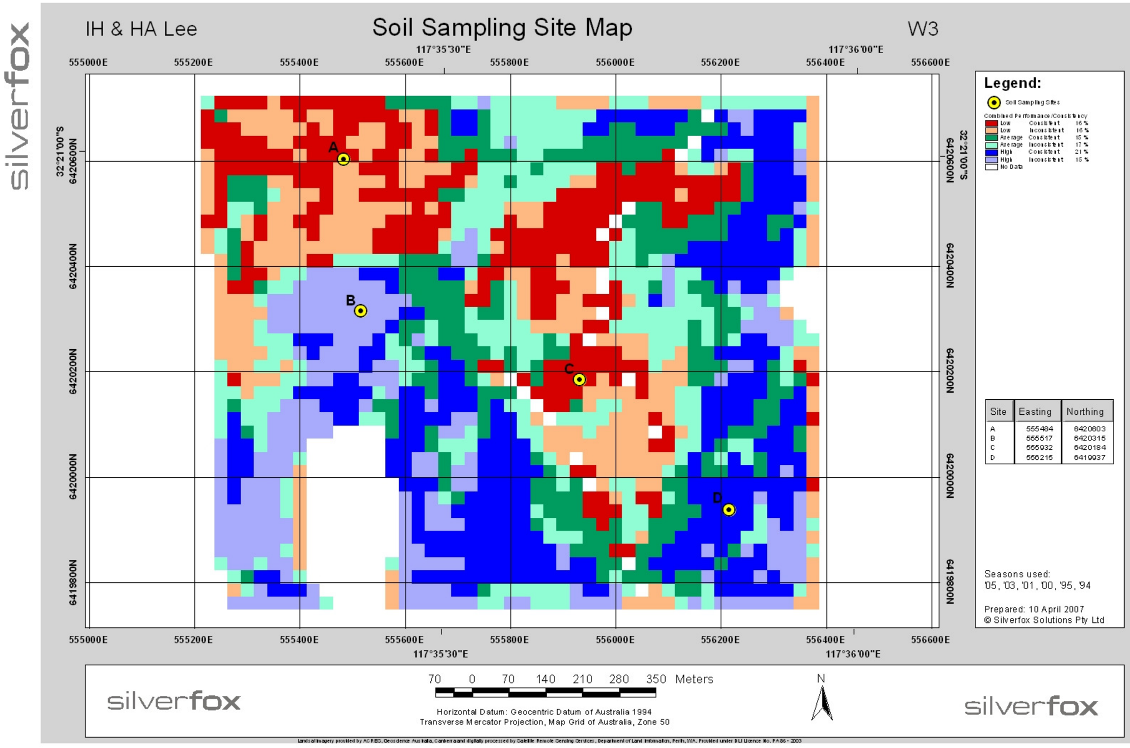

Figure 1. NDVI image showing crop biomass and paddock stability through time.

Soil tests

Soil tests were undertaken in each zone. The results indicated that the phosphate rates were very high and it was unlikely there would be any response to applied phosphate, especially given the low to medium reactive iron levels (Table 1). Soil phosphate rates ranged from 39 to 64 ppm.

The soil had high potassium and sulphur levels and the pH ranged from 4.8 to 5.2.

The paddock was most likely to be responsive to applied nitrogen, given it was a grass based pasture in 2006 and had fairly low soil nitrate levels.

Table 1. Soil test results

Productivity zone	pH (CaCl)	Organic carbon	Nitrate nitrogen	Ammonium nitrogen	P (Colwell)	Reactive iron	Potassium (Colwell)
Poor	5.5	1.22	8	6	51	309	242
Good/stable	5	1.45	12	3	41	360	206
Good/unstable	5.2	1.75	9	8	43	468	159

Target yields were set for each productivity zone pre seeding (Table 2) and then Nulogic® was used to determine the optimum fertiliser rates for each zone to achieve the target yield.

Due to the late break to the season the paddock was not sown until the 16 June. This was 2-3 weeks later than the ideal time of sowing so target yields were revised down and post emergent fertiliser treatments were also amended using Nulogic® to reflect this (Table 3).

The fertiliser treatments ranged from Nil on the low productivity zone to the farmer treatment of 9 kg P and 40 kg N costing $96/ha (Table 3)

Table 2. Fertiliser recommendation to achieve target yield

Treatment	Target yield	P rate	N rate
Low	1.5 t	0	0
Medium	2.5 t	0	40
High	3.5 t	0	80
Farmer		9	40

Table 3. Revised fertiliser recommendation to achieve target yield

Treatment	Target yield (t/ha)	P rate (kg/ha)	N rate (kg/ha)	Cost ($/ha)
Low	1.5 t	0	0	0
Medium	2.0 t	0	20	25
High	3.0 t	0	59	70
Farmer	2.3 t	9	40	96

Economic calculations

Financial calculations used 2007 list fertiliser prices. The grain prices were calculated individually for each treatment using the January 2008 AWB golden rewards premiums and discounts. The prices used were a rolling 5 year average Farm gate price. This was chosen to minimise the massive fluctuations in wheat price over the life of the project.

RESULTS

Grain Yield and Economics

Even though there was a late break to the season, above average spring rainfall resulted in very high grain yields (1.4 to 3.5 t/ha). The growers target yield for the paddock was 2.3 t/ha, however, the paddock averaged 2.6 t/ha. This was a good result given the late break to the season.

Table 3. Grain yield, quality and price of each fertiliser treatment in poor, average and good productivity zones

	Input	Yield (t/ha)	Hect wt	Screenings (%)	Protein (%)	Pay Grade	Price ($/t)
Poor Zone	Low	2.5	80	3.8	8.2	ASF1	265
	Medium	3.1	80	3.7	8.8	ASF1	263
	High	3.5	81	3.1	9.5	ASF1	265
	Farmer	3.35	81	3.4	9	ASF1	263
Good Unstable Zone	Low	1.5	80	3.1	8.9	ASF1	265
	Medium	1.75	81	2.9	9.1	ASF1	262
	High	1.75	79	3.3	9.9	GP1	243
	Farmer	1.85	80	3	9.2	ASF1	264
Good Stable Zone	Low	2.1	82	1.2	8	ASF1	269
	Medium	2.5	82	1.7	8.5	ASF1	269
	High	2.8	81	1.9	9	ASF1	267
	Farmer	2.9	80	1.6	8.2	ASF1	269

Zone performance

The zones within the paddock did not perform as predicted by the Silverfox biomass analysis. The zone identified as poor producing was the highest yielding zone. The good producing unstable zone was significantly poorer yielding than the other zones (Figure 2). The different performance of the zones is likely to be a result of the new management and seasonal conditions. The area identified as poor producing can often waterlog, however the moisture gaining properties of this site were beneficial in the dryer season of 2007 resulting in the highest yields in the paddock.

Figure 2 shows the gross returns of each fertiliser treatment (Blue, Green, Yellow and Pink bars) in each productivity zone. The actual yield is featured above each column. The red bars represent the cost of fertiliser, seed and application.

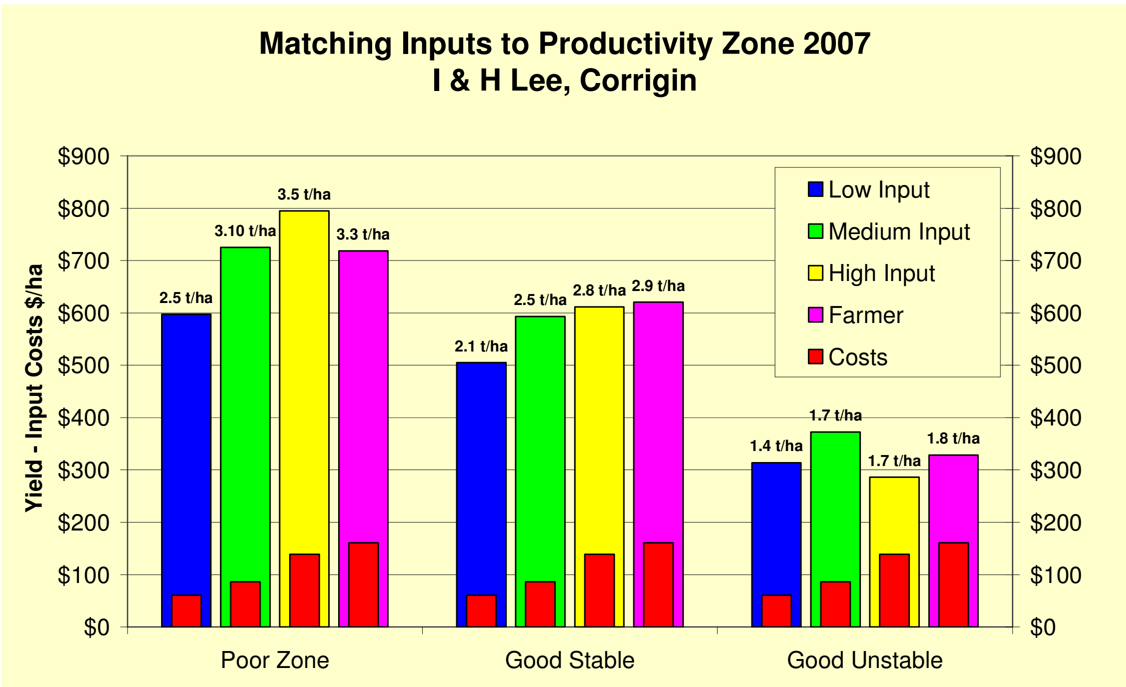

Figure2. Economics of matching inputs to productivity zones.

Treatment performance across zones

Low input

The low input treatment was a nil fertiliser treatment. This treatment was the least profitable treatment when averaged across the paddock (Figure 2 and Table 4) returning $8,600 less than the medium fertiliser treatment. These results show that as the yield potential is higher the cost of under fertilising is greatest. Where the yield potential is lower the low fertiliser treatment performs well.

Medium input

A blanket application of medium input (20 kg/N/ha) treatment was the most profitable way to fertilise the paddock. This generated between $1,400 and $8,600 more than the other treatments.

High input

A blanket application of the high input treatment (59 kg N) was the second most profitable way to fertilise the paddock (Table 4).

VRT treatment

The VRT treatment using the predicted zones (high on good stable zone, medium on unstable good zone and low input on poor zone) returned $3,600 less than the most profitable treatment (blanket medium inputs).

If the biomass analysis had predicted the zones correctly (the biomass image incorrectly identified the good stable and unstable zones – the high and poor actually were switched) and the high input was applied to the best performing area and the medium treatment to mid performing zone and the low input was applied to the poorest zone, then this treatment would have been the most profitable treatment returning $53,540 or $410 more than the blanket application of medium inputs.

This highlights the importance of accurately predicting the productivity zones within paddocks when adopting VRT. It also identifies the difficulty of managing seasonal variability in zone performance due to variations in soil moisture. For example, a waterlogged site in a wet season is a poor performer but in a dry season it is a high performing zone due to the good moisture availability.

Farmer treatment

The farmer fertiliser treatment (9 kg P and 40 kg N) was the most expensive fertiliser treatment costing $96/ha. In all zones it performed similar or between the high (59 kg N) and the medium treatment (20 kg N). This shows that the majority of the response was a nitrogen response and there was very little response to the applied phosphate. This was predicted given the very high soil phosphate levels.

Table 4. Cost or benefit of matching fertiliser inputs to productivity zones.

	Ha	Low	Medium	High	VRT	Farmer
Poor	32	19 125	23 170	25 430	19 125	22 985
Good Unstable	47	14 745	17 505	13 455	17 505	15 430
Good Stable	21	10 605	12 455	12 835	12 835	13 030
Paddock total value	**100**	**44 475**	**53 130**	**51 720**	**49 465**	**51 445**
Difference from medium input		- $8 655	0	- $1 410	- $3 665	- $1 685

Conclusion

The results from this trial show that VRT can be profitable provided that the performance of each zone can be predicted and is consistent through time. In this trial the biomass image analysis was a poor predictor of zone performance making VRT less profitable.

Profitable crops can be grown without phosphate (in short term) where soil phosphate levels are high (> 40 ppm) and reactive irons are low to medium. While sowing crops with nil phosphate is extreme and not recommended in most situations it should give growers confidence to at least reduce rates in these situations.

Where a change in farming system or farmer, historical biomass maps can be a poor predictor of zone performance in this example knife points and early sowing enabled the historically poor performing area to be the top performing zone of the paddock due to overcoming waterlogging.

MATCHING INPUTS TO PRODUCTIVITY ZONES CFIG 2006

N & G Turner

KEY MESSAGES

- 2006 was a high production year with yields ranging from 2 t to 3.9 t/ha from the poor productivity zone to the high productivity zone.
- In 2006, there was a net benefit of $2,693 in this paddock from matching fertiliser inputs to productivity zones (VRT) compared to applying a blanket rate across the whole paddock. This represents an increase in returns of 5 per cent.
- If the whole paddock had a blanket application with the high input treatment there would only be a $740 benefit compared to the medium input in 2006. This is a small additional return given the extra financial risk associated with spending an extra $37/ha on fertiliser. In an average or poor season the high input treatment would be highly unprofitable

AIMS

To better match fertiliser inputs to productivity zones to increase whole paddock profitability.

To document and evaluate a practical procedure utilising tools and services that are readily available for zoning paddocks and matching fertiliser inputs to productivity zones.

METHODS

Target yields for each productivity zone were set using the biomass images and farmer experience.

Soil testing was undertaken in each zone at a depth of 0-10 cm and 10-20 cm. The Nulogic® crop nutrition model was used to generate the fertiliser requirements to achieve the target yield in each productivity zone

Paddock details

The trial paddock was a sand plain soil type ranging from loamy sand to deep white sand and was located high in the landscape. The paddock grew lupins in 2004 and this was the second year of Calingiri wheat.

The paddock was un-grazed over summer and the stubble was burnt in late autumn prior to sowing. The paddock received 266 mm of rain during January, February and March. It was a dry winter and the crop received 180 mm of growing season rainfall.

Calingiri wheat was sown on 3 June 2006 at 60 kg/ha.

The standard paddock fertiliser (outside the trial) was 70 kg Vigour zincstar and 80 kg Urea providing 50 kg N, 10 kg P and 12 kg K.

The site was tissue tested in August to evaluate nutrient uptake and to ensure that there were no trace element deficiencies that would influence the trial results. The paddocks were also flown by Air Agronomics to assess crop biomass in response to the nutrition treatments.

Soil test

Soil tests indicated that the site had relatively high phosphate levels and low to ideal reactive iron levels (see Table 1). This meant that the site was unlikely to be responsive to phosphate. The soil nitrogen levels were low and the paddock was wheat on wheat and the site was expected to be responsive to nitrogen. Table 2 shows the target yield for each productivity zone and the recommended rate of nitrogen and phosphate to achieve the target yield.

Table 1. Soil test results

Productivity zone	pH (CaCl)	Organic carbon	Nitrate nitrogen	Ammonium nitrogen	Phosphorus (Colwell)	Reactive iron	Potassium (Colwell)
Poor	4.8	0.46	8	1	21	127	34
Average	5.2	1.76	8	2	33	682	102
Good	5.5	1.37	17	1	23	488	81

Note: Sub soil data not included.

Table 2. Fertiliser recommendations to achieve target yield

Fertiliser treatment	Target yield t/ha	Phosphate kg/ha	Nitrogen kg/ha	Potassium kg/ha	Cost $/ha
Low	1	5	11	3.5	$27
Medium	2	10	30	6.7	$59
High	3	10	65	6.7	$96

TRIAL DESIGN

The trial design was a fully randomised design with 3 replications. It was also identified that the paddock had 2 areas of poor and average production and a plot was placed in each. The averages for the two plots were combined to form one management unit.

The trial was sown with the farmer's air seeder so that a seeding run would pass through at least two of the productivity zones. The plots were a full air seeder width wide and yield was measured with a weigh trailer from a minimum plot length of 100 m in each zone.

Economic calculations

All financial calculations used 2006 list fertiliser prices. The grain prices were calculated individually for each treatment using the December 2006 AWB golden rewards premiums and discounts and a 5 year average FOB price. The prices were then converted back to a farm gate price. The calculated returns for each treatment represent gross income minus fertiliser and application cost.

RESULTS

Grain yield and economics

All three productivity zones yielded very well, exceeding target yields by between 0.5-1 t/ha (Table 3). The zones performed as expected with the highest yield in the good, average and poor zones 3.65, 2.89 and 2.2 t/ha respectively.

The highest yield and returns in the poor productivity zone were achieved with the medium fertiliser input. This is not surprising given the grain yields were at least 1 t/ha greater than the target yield. The 2006 rainfall pattern allowed for efficient use of applied fertiliser and adequate rainfall to optimise yields.

In the average productivity zone the medium and high input treatments achieved similar yields and grain quality; however the additional costs of the high input treatment meant that it generated lower returns (Figure 1). All three treatments failed to make ASWN quality because of low protein.

Table 3. Grain yield, quality and price of each fertiliser treatment across productivity zones

	Input	Yield (t/ha)	Hect wt	Screenings (%)	Protein (%)	Moisture (%)	Pay grade	Price ($/t)
	Low	2.03	82.1	3.2	9.5	10.1	ASWN	$206.00
Poor zone	Medium	2.49	81.5	3.2	10.1	10.0	ASWN	$213.50
	High	2.19	81.5	3.0	9.8	10.0	ASWN	$211.00
	Low	2.58	81.5	1.8	8.9	10.0	ASW	$182.50
Average zone	Medium	3.03	82.1	1.7	9.1	9.9	ASW	$186.00
	High	3.06	81.6	2.5	9.4	9.9	ASW	$188.50
	Low	3.46	80	3.2	9.2	9.9	ASW	$184.00
Good zone	Medium	3.55	81	2.2	8.9	9.9	ASW	$182.00
	High	3.94	80	3.2	9.5	9.8	ASWN	$206.00

In the good productivity zone the high input treatment achieved the highest yield and returns (Table 3). The returns were further improved by the high input treatment achieving ASWN where as the medium and low inputs were down graded to ASW because of low protein.

Figure 1 shows the gross return minus fertiliser cost for the low, medium and high inputs in the good, average and poor productivity zones. The black bars represent fertiliser expenditure.

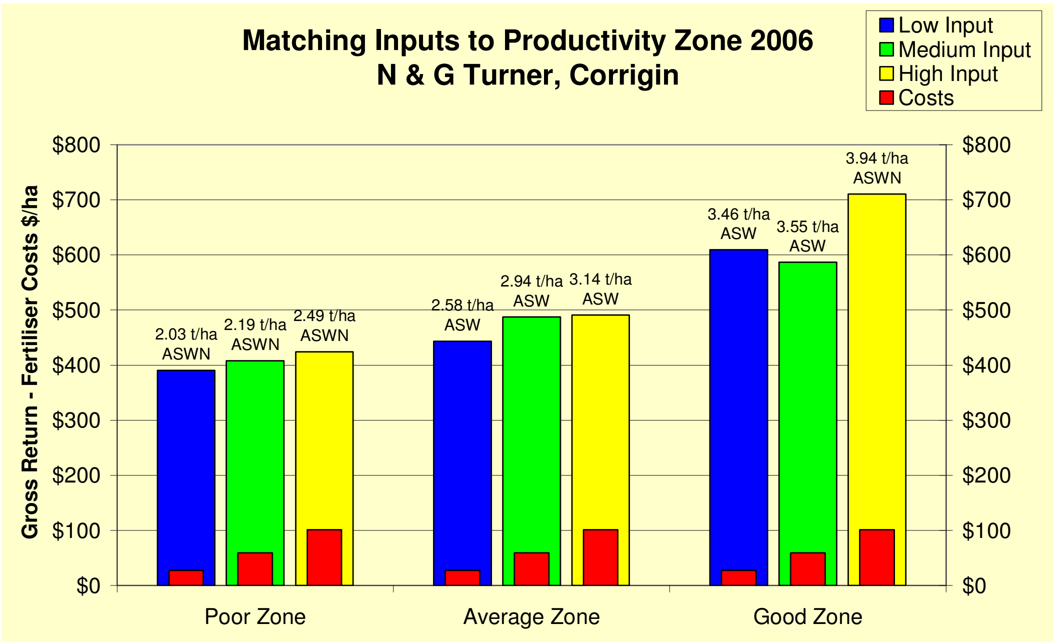

Figure 1. Economics of matching inputs to productivity zones.

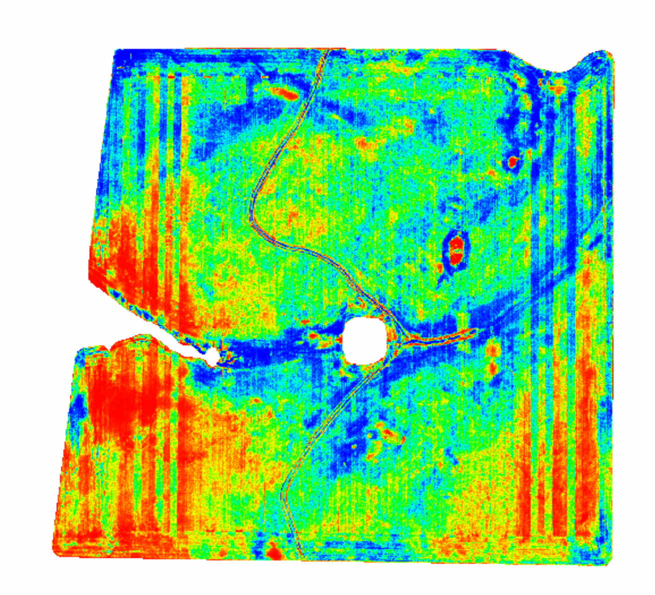

Figure 2. NDVI image showing crop biomass and plot biomass responses to fertiliser treatments.

Figure 3 Striping visible August 2006. Dark green is high input

Zone management vs blanket treatment

To calculate the benefit or cost of managing this paddock according to productivity zone we extrapolated the findings across the whole paddock according to the areas of each zone in the paddock (Table 4). In this example VRT assumes fertiliser rates based on target yield in a zone; good (high input), average (medium input) and poor (low input). The unstable areas of the paddock that fluctuate in performance from year to year were included in the average productivity zone.

This shows that in 2006, there would have been a net benefit of $2,693 in this paddock from matching fertiliser inputs to productivity zones (VRT) compared to applying the medium treatment as a blanket across the whole paddock. While this additional income is a step in the right direction it only represents a 5 per cent increase in returns. Given the financial and time costs involved in setting up a VRT system many farmers would want a substantially greater increase in returns than 5 per cent to warrant adoption.

If the whole paddock was blanketed with the high input treatments there would only be a $740 benefit compared to the medium input in 2006. This is a small additional return given the extra financial risk associated with spending an extra $37/ha on fertiliser. In an average or poor season the high input treatment would be highly unprofitable.

Table 4. Cost or benefit of matching fertiliser inputs to productivity zones

	Ha	Low	Medium	High	VRT
Poor	10	3 910	4 720	3 610	3 910
Average	59	26 137	29 736	28 084	29 736
Good	31	18 879	18 197	21 700	21 700
Paddock gross income		**48 926**	**52 653**	**53 394**	**55 346**
Difference from medium input		**-$3 727**	$0	**$741**	**$2 693**

CONCLUSION

2006 was a high production year with yields ranging from 2 t to 3.9 t/ha from the poor productivity zone to the high productivity zone.

The season allowed for efficient use of applied and soil nutrients, with minimal leaching events, yet adequate rainfall to allow the crops to finish well and achieve above average yields in all productivity zones.

In 2006, there would have been a net benefit of $2,693 in this paddock from matching fertiliser inputs to productivity zones (VRT) compared to applying a blanket rate across the whole paddock. This represents an increase in returns of 5 per cent.

If the whole paddock was blanketed with the high input treatments there would only be a $740 benefit compared to the medium input in 2006. This is a small additional return given the extra financial risk associated with spending an extra $37/ha on fertiliser. In an average or poor season the high input treatment would be highly unprofitable.

This trial will be repeated in 2007 to investigate the compounding effects of the previous season’s fertiliser regime on each plot.

MATCHING INPUTS TO PRODUCTIVITY ZONES CFIG 2007

N & G Turner

KEY MESSAGES

- 2007 was a high production year with yields ranging from 2.1 t to 3.5 t/ha from the poor to the high productivity zone.
- In 2007, there would have been a net loss of $2,700 in this paddock from matching fertiliser inputs to productivity zones (VRT) compared to applying a blanket rate of medium inputs across the whole paddock.
- If the whole paddock was blanketed with the high input treatments there would have been a $5700 loss compared to the medium input in 2007. There was a minimal yield response to the additional fertiliser (even in an above average season) and it failed to cover the additional cost of fertiliser.
- Blanket application of medium inputs (8 kg P, 65 kg N and 5 kg K) was the most profitable treatment of the trial which was surprising given the paddock had light soil, a high yield and was the third cereal crops in a row.

AIMS

To better match fertiliser inputs to productivity zones to increase whole paddock profitability.

To investigate the compounding effect of varying rates of inputs on the same plots two years in a row.

METHODS

Paddock details

Rotation: Lupins 2004/Wheat 2005/Wheat 2006/Wheat 2007

Jitarning wheat was sown on 25 May at 65 kg/ha.

Paddock fertiliser: 80 kg Vigour zincstar and 80 kg Urea providing 41 kg N, 10 kg P and 10 kg K.

The site was tissue tested in August to evaluate nutrient uptake and to ensure that there were no trace element deficiencies that would influence the trial results. The paddocks were also flown by Air Agronomics to assess crop biomass in response to the nutrition treatments.

Soil test

Soil testing was undertaken in 2006 and 2007 in each zone at a depth of 0-10cm and 10-20 cm. The Nulogic® crop nutrition model was used to generate the fertiliser requirements to achieve the target yield in each productivity zone

The trial paddock was a sand plain soil type ranging from loamy sand to deep white sand and was located high in the landscape. The paddock grew lupins in 2004 and Calingiri wheat in 2005. The trial was sown to Calingiri and Jitarning over 2006 and 2007 respectively.

Soil tests indicated that the site had relatively high phosphate levels and low to ideal reactive iron levels (See Table 1). This meant that the site was unlikely to be responsive to phosphate. The soil nitrogen levels were low and the paddock was wheat on wheat and the site was expected to be responsive to nitrogen.

Table 2 shows the target yield for each productivity zone and the recommended rate of nitrogen and phosphate to achieve the target yield.

Table 1. Soil test results

Productivity zone	pH (CaCl)	Organic carbon	Nitrate nitrogen	Ammonium nitrogen	Phosphorus (Colwell)	Reactive iron	Potassium (Colwell)
Poor	5	0.71	5.5	3	20	167	29
Average	5.2	1.12	10.5	5.5	31	421	83
Good	5	1.41	9	7	30	483	132

Note: Sub soil data not included.

Table 2. Fertiliser recommendations to achieve target yield

Fertiliser treatment	Target yield t/ha	Phosphate kg/ha	Nitrogen kg/ha	Potassium kg/ha	Cost $/ha
Low	2	3	30	2.4	$40
Medium	3	8	65	5.3	$90
High	4	13	100	8.6	$140

TRIAL DESIGN

The trial was sown with the farmer's air seeder so that a seeding run would pass through at least two of the productivity zones. The plots were a full air seeder width wide and yield was measured with a weigh trailer from a minimum plot length of 100 m in each zone.

Trial designs were a fully randomised design with three replications.

Low, medium and high input treatments were repeated on the same sites in 2007 as 2006. This tests the compounding effect of the previous seasons fertiliser strategy.

Target yields for each productivity zone were set using the biomass images and farmer experience.

Economic calculations

Financial calculations used 2007 list fertiliser prices. The grain prices were calculated individually for each treatment using the January 2008 AWB golden rewards premiums and discounts. The prices used were a rolling 5 year average Fob price. This was chosen to minimise the massive fluctuations in wheat price over the life of the project.

RESULTS

Grain yield and economics

2007 was a high yielding season with an average yield across the trial of 2.88 t/ha, all treatment plots made A. Soft grade.

As expected the poor productivity zone was the lowest yielding with an average yield of 2.5 t/ha. The average zone had the highest yields (3.23 t/ha).

In all zones the highest returns (not necessarily highest yield) were achieved with the medium fertiliser input. In the poor zone the high input treatment had a suppressed yield compared to the medium input (Figure 1).

In the average and good productivity zones the highest yield was achieved by the high input treatments however the increased yield did not cover the additional cost of fertiliser.

Table 3. Grain yield, quality and price of each fertiliser treatment across productivity zones

	Input	Yield (t/ha)	Hect wt	Screenings (%)	Protein (%)	Moisture (%)	Pay grade	Price ($/t)
	Low	2.13	81.3	1.1	8.7	10	A. Soft	$272
Poor zone	Medium	2.90	81.7	1.4	9.3	10	A. Soft	$269
	High	2.50	81.4	1.5	9.0	10	A. Soft	$269
	Low	2.80	80.9	1.4	8.1	10	A. Soft	$272
Average zone	Medium	3.44	81.1	1.1	8.8	10	A. Soft	$272
	High	3.46	82.0	1.2	8.4	10	A. Soft	$272
	Low	2.45	80.2	1.9	7.9	10	A. Soft	$272
Good zone	Medium	3.04	80.3	2.6	8.1	10	A. Soft	$269
	High	3.19	79.4	3.0	9.1	10	A. Soft	$264

Figure 1 show the gross return minus fertiliser cost for the low, medium and high inputs in the good, average and poor productivity zones. The black bars represent fertiliser expenditure.

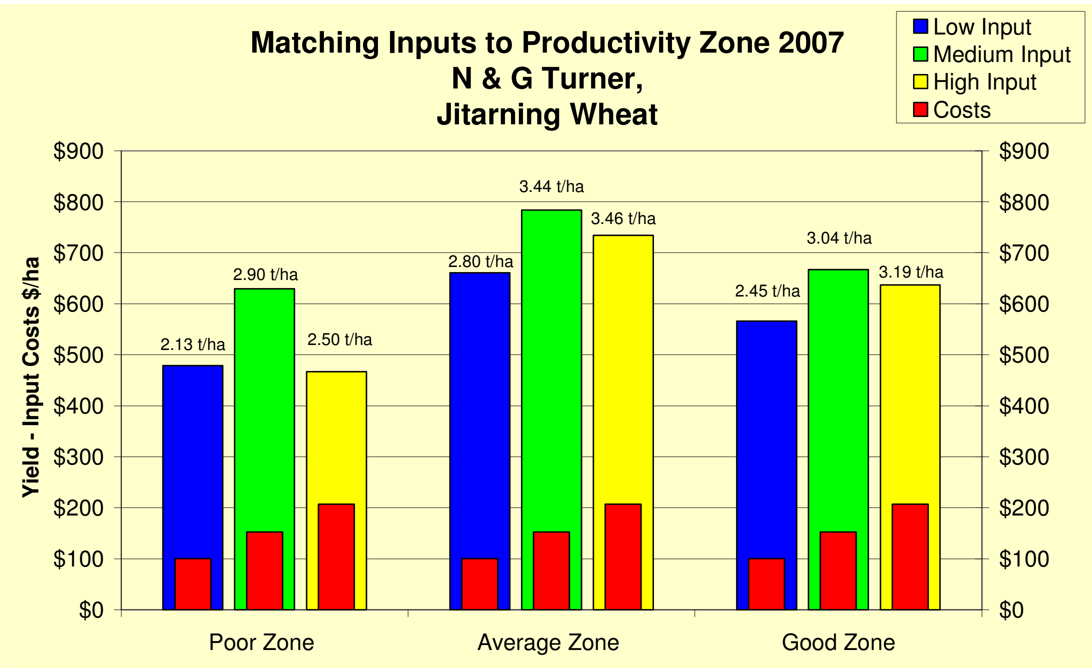

Figure 1. Economics of matching inputs to productivity zones.

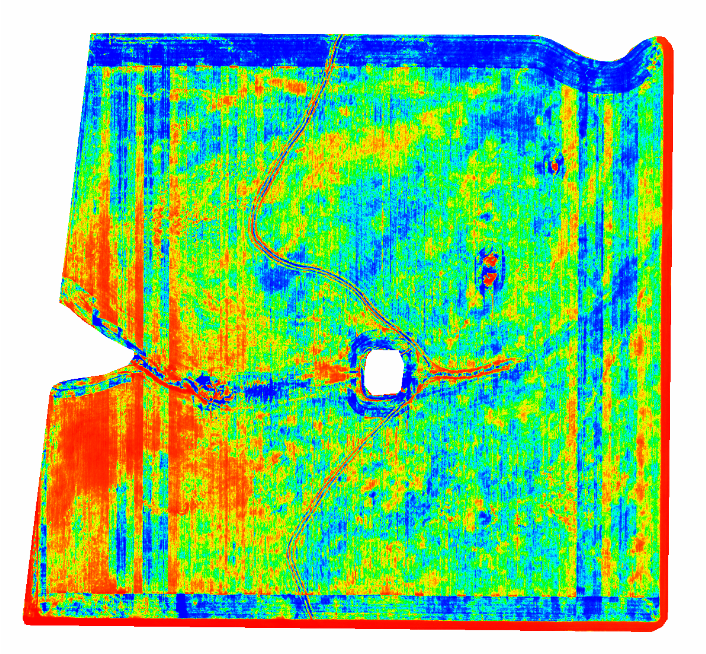

Figure 2. NDVI image showing crop biomass and plot biomass responses to fertiliser treatments.

Figure3. Photos showing striping visible in poor zone (left) and average zone (right).

Zone management vs blanket treatment

To calculate the benefit or cost of managing this paddock according to productivity zones we extrapolated the findings across the whole paddock according to the areas of each zone in the paddock (Table 4). In this example VRT assumes fertiliser rates based on target yield in a zone; good (high), average (medium) and poor (low).

Table 4 shows that in 2007 there would have been a net loss of $2,700 if the paddock was treated with VRT. The most profitable option was the blanket treatment of medium input. Blanket low input would have cost $12,100 and blanket high input would have cost $5,700 compared to the medium input.

Table 4. Cost or benefit of matching fertiliser inputs to productivity zones

	Ha	Low	Medium	High	VRT
Poor	10	4 800	6 600	4 700	4 800
Average	59	39 000	46 200	43 300	46 200

Good	31	17 500	20 700	19 700	19 700
Paddock gross income		**61 300**	**73 500**	**67 700**	**70 700**
Difference from medium input		**-$12 100**	**$0**	**-$5 700**	**-$2 700**

CONCLUSION

2007 was a high yielding season with an average yield across the trial of 2.88 t/ha and a range from 2.1 t to 3.5 t/ha, all treatment plots made A. Soft grade.

The rainfall pattern in 2007 allowed for efficient use of applied and soil nutrients which enabled treatments to optimise yield.

The results from this trial suggest that there is unlikely to be large efficiency gains by matching fertiliser inputs to productivity through variable rate technology (VRT). In 2007, there would have been a net loss of $2,700 in this paddock from matching fertiliser inputs to productivity zones (VRT) compared to applying a blanket rate of medium inputs across the whole paddock.

If the whole paddock was blanketed with the high input treatments there would have been a $5700 loss compared to the medium input in 2007. There was a minimal yield response to the additional fertiliser (even in an above average season) and it failed to cover the additional cost of fertiliser.

Blanket applications of medium inputs (8 kg P, 65 kg N and 5 kg K) was the most profitable treatment of the trial which was surprising given the paddock has light soil, high yield and was the third cereal in a row.

These results show that growers need to take care not to over fertilise crops above realistic target yields and that fertilising for the average season is a sound strategy as the soil can usually supply the additional required phosphate if reactive irons levels are low and there is sound phosphate levels in the soil.

MATCHING INPUTS TO PRODUCTIVITY ZONES CFIG 2006

S. Wallwork

KEY MESSAGES

- 2006 was a dry season at east Corrigin, especially for canola on heavy clay soil types.
- Plant establishment and survival in the poor and average productivity zones was to low to justify harvesting for trial purposes.
- The good productivity zone yielded below 200 kg/ha of Canola so there were no economic responses to fertiliser treatments.

AIMS

To investigate if matching phosphate rates to productivity zone increases whole paddock profitability when sowing canola.

METHODS

This trial site is located east of Corrigin on a heavy red soil with high phosphate binding. Most of the previous PA trial sites have been located west of Corrigin on sandy soil types with low to medium ability to bind applied phosphate.

Paddock Details

Stubby canola was sown on the 7 April 2006 at 3-3.5 kg/ha. The canola was sown with a DBS air seeder on 50m cm spacings. The whole paddock was deep ripped with a single pass during seeding.

The DBS was set up to deep rip by removing every second tine and re-mounting it one behind the other so that there was a leading tine followed by another at 30 cm. The parallelogram seeding system of the DBS allowed the canola to be evenly sown at normal depth.

See attached paper in Appendix covering investigations of deep ripping.

Rotation: Pasture 2002/wheat 2003/wheat 2004/wheat 2005/canola

The site was tissue tested in August to evaluate nutrient uptake and to ensure that there were no trace element deficiencies that would influence the trial results. The paddock was also flown by Air Agronomics to assess crop biomass in response to the nutrition treatments.

Soil Test

The soils in this paddock ranged from lake bank loams, salmon gum clays to red crumbling gimlet soil types. This trial site provided a good contrast to the previous PA research sites and soil types.

Soil testing was undertaken in each zone at a depth of 0-10 cm and 10-20 cm.

The soil contained generally good P levels (>27) except the poor performing areas (16ppm) which was surprising given it poor performance. It was expected this area would have accumulated P since clearing.

The soils contained high soil nitrate levels from mineralisation as a result of good summer rains. The NuLogic® model suggested that the site should only require 30 kg of N to achieve a 1.5-2 t canola yield. This was driven by the high nitrate levels.

Table 1. Soil test results by productivity zone

	pH	Organic carbon	Nitrate	P	Reactive iron	K	S
Poor	7.7	0.89	39	16	911	677	9.3
Average	7.8	1.48	58	29	641	1093	12.1
Good	7.7	1.48	56	27	594	1186	12

Note – sub soil samples are not shown

Fertiliser treatments

The Nulogic® crop nutrition model was used to generate the fertiliser requirements to achieve the target yield in each productivity zone.

The paddock had varied phosphate rates according to target yield in each productivity zone. Nitrogen rates were blanketed at seeding with all plots receiving 30 L of Flexi N at seeding. The medium and high plots were to be topped up with an additional 20 and 40 L of Flexi N, however due to the dry season and patchy establishment it was decided that the crop would be unresponsive to extra nitrogen.

Table 2. Fertiliser treatments

Input	Target yield t/ha	P rate kg/ha	N rate kg/ha	Double phos kg/ha	Flexi N L/ha	Cost $/ha
Low	1	3.5	12.5	20	30	$20
Medium	1.5	10	12.5	60	30	$37
High	2	18	12.5	100	30	$54

TRIAL DESIGN

The trial was a randomised block design with 3 replications, 1 air seeder width wide crossing all three productivity zones. The target yields for each productivity zone were set using the biomass images and farmer experience. It was assumed that canola performance matched that of cereal crops.

Economic calculations

The economics for the trial used 2006 list fertiliser price and a 5 year average farm gate price for the canola of $500/t. Agracorp premiums and discounts were used to derive the individual plot grain price.

RESULTS

The trial site was extremely restricted by the poor growing season, resulting in patchy establishment and poor plant survival. The crop required protection from aphids (which caused some chewing damage) in April and May and by June the aphids had built up to spray threshold levels on the moisture stressed crop. The spray provided effective control of the aphids. However there was a sharp finish to the season (see below) resulting in a failed canola crop.

Table 3. Rainfall 2006 in mm

Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov	Dec.
187	43.5	26	18	9.5	20	28.8	37	23	3.5	18.5	0

The good productivity zone was the only area of the paddock worth harvesting. In the average and poor productivity zone there was not adequate plant establishment or plant survival for meaningful trial data.

Table 3. Grain yield and economics in good productivity zone

	Yield	Oil	Gross return	Gross return – fertiliser cost
Low	0.182	35.9	$80	$60
Medium	0.193	35.4	$85	$48
High	0.161	35.3	$71	$17

Table 4 shows that even in the best area of the paddock the crop yield was significantly damaged by the tough seasonal conditions. With yields below 200 kg/ha there was not going to be an economic response to increasing fertiliser rates.

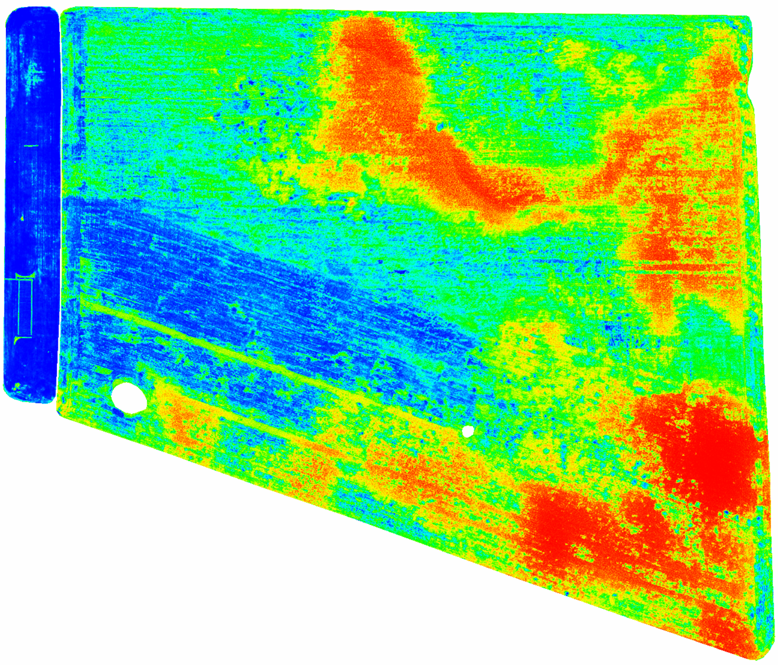

Figure 1. NDVI image showing crop biomass and plot biomass responses to fertiliser treatments.

CONCLUSION

2006 was a dry season at east Corrigin, especially for canola on heavy clay soil types.

Plant establishment and survival in the poor and average productivity zones was to low to justify harvesting for trial purposes.

The trial was repeated in 2007 with a cereal crop (see next page for results). The low, medium and high input treatments were repeated over the same sites to evaluate the compounding effects of the previous season's fertiliser treatments.

MATCHING INPUTS TO PRODUCTIVITY ZONES CFIG 2007

S. Wallwork

KEY MESSAGES

- The site proved to be very unresponsive to phosphate with very little yield differences between any of the fertiliser treatments.
- Treatments of low (nil N and P) and medium (10kg P and kg N) fertiliser input generating the greatest returns. The high input treatment resulted in a loss of over $4500 compared to the medium input.
- The trial was repeated in 2006 and 2007 with low medium and high inputs repeated on the same sites.

AIMS

To investigate if matching phosphate rates to productivity zone increases whole paddock profitability when sowing barley.

To investigate the effect of the previous seasons fertiliser strategy on 2007 barley production.

METHODS

See 2006 trial report for soil type descriptions.

Paddock details

Baudin Barley was sown at 50 kg/ha on the 30 April into marginal moisture, with a DBS knife point seeder on 25 cm row spacings.

Rotation: Pasture/wheat/wheat/wheat/canola/barley.

Zoning paddocks and estimating crop nutrition requirements

The Nulogic® crop nutrition model was used to generate the fertiliser requirements to achieve the target yield in each productivity zone.

The site was tissue tested in August to evaluate nutrient uptake and to ensure that there were no trace element deficiencies that would influence the trial results. The paddocks were also flown by Air Agronomics to assess crop biomass in response to the nutrition treatments.

Soil test

Soil testing was undertaken in each zone and across input plots from 2006 at a depth of 0-10 cm and 10-20 cm. The soil contained good P levels, however it was surprising that the low yielding poor productivity zone had the lowest P levels of the paddocks, given there was very little grain removal on this soil type in 2006. It was expected this area would have accumulated P since clearing.

The soils contained high nitrate levels from mineralisation as a result of the drought affected canola crop in 2006. Note that the nitrates are highest in the average and poor productivity zones where the canola was un-harvestable the previous season.

The NuLogic® model suggested that the site should not require any additional nitrogen to achieve the target yields of barley (1-3.5 t). It also indicated that the site was likely to be P responsive due to the high reactive iron and alkaline pH levels.

Table 1. Soil test results

	pH	Organic carbon	Nitrate	P	Reactive iron	K	S
Poor	7.5	1.21	95	24	911	563	11.5
Average	7.6	1.37	107	36	641	575	15.5
Good	7.1	1.58	33	27	594	1260	10.8

Fertiliser treatments

The paddock had varied phosphate rates on the same sites in 2006 and 2007 according to target yields in each productivity zone. The nitrogen required to achieve target yield (1-3.5 t) was nil, however plots received some nitrogen with the compound fertiliser (Table 2).

Table 2. Fertiliser treatment for each target yield

Fertiliser treatment	Target yield t/ha	P rate	Agflow	N	Cost $/ha
Low	IT	0	0	0	0
Medium	2.5 t	10	55	7.34	$36
High	3.5 t	16	90	11.5	$59

TRIAL DESIGN

The trial was a randomised block design with 3 replications, one air seeder width wide. The trial in 2007 was a repeat of the 2006 trial with updated soil test data to derive the nitrogen and phosphate requirements to achieve the target yields.

Baudin barley was sown onto the canola stubble from 2006. The low, medium and high input treatments were repeated over low, medium and high treatments from 2006. This enabled the evaluation of the compounding effect of the previous season’s fertiliser regime.

Economic calculations

Gross margins were calculated using 5 year average grain prices. This was done to smooth out the impact of rapid fluctuations in grain price as these trials have been repeated over a number of seasons. For this trial a feed and Malt price of $220/t and $260 (net farm gate) was used.

2007 was a dry year for the east Corrigin trial site with an annual rainfall of 186 mm and a growing season rainfall of 164 mm. A dry August and September had the largest limiting impact on grain yield, however late rain in October prevented crop failure. Grain yields ranged from 1.5 t/ha to 1.9 t/ha. However, as shown in Table 3, the grain was all graded as feed grade due to high screenings.

RESULTS

Table 1. Grain yield, quality and price for each fertiliser treatment in poor, average and good productivity zones

	Input	Yield (t/ha)	Hect wt	Screenings (%)	Protein (%)	Moisture (%)	Pay grade	Price ($/t)	Gross return/ha
Poor zone	Low	1.51	70.0	48.8	14.2	10.0	Feed	220.0	331
	Medium	1.71	68.3	48.7	14.3	10.0	Feed	220.0	375
	High	1.78	68.6	47.9	14.4	9.6	Feed	220.0	391
Averag e zone	Low	1.72	68.7	36.4	14.3	9.9	Feed	220.0	379
	Medium	1.93	68.7	42.6	14.3	9.4	Feed	220.0	425
	High	1.80	68.4	47.6	14.6	9.9	Feed	220.0	395
Good zone	Low	1.83	68.9	34.3	14.6	9.7	Feed	220.0	402
	Medium	1.86	68.5	32.6	14.5	9.5	Feed	220.0	410
	High	1.84	68.4	34.2	14.8	9.6	Feed	220.0	405

Grain yield and economics

In 2007 the average and good productivity zones had similar grain yields of just over 1.8 t/ha averaged across all fertiliser treatments. However the poor performing zone had a lower average yield of 1.67 t/ha.

Figure 2 shows the gross returns minus fertiliser cost for the low, medium and high inputs in the good, average and poor productivity zones. The red bars represent fertiliser, seed and chemical cost of each treatment. The actual plot yield is listed above each bar in the figure.

The most profitable treatment in the trial was the low input treatment in the high productivity zone. This treatment was a nil fertiliser treatment. The site proved to be very unresponsive to phosphate with very little yield differences between any of the fertiliser treatments.

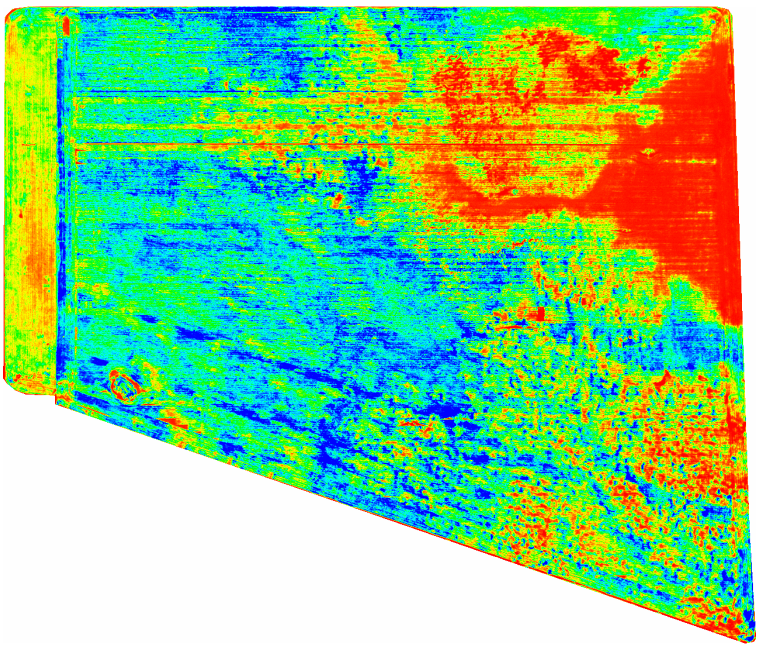

Figure 1. NDVI image showing crop biomass and plot biomass responses to fertiliser treatments.

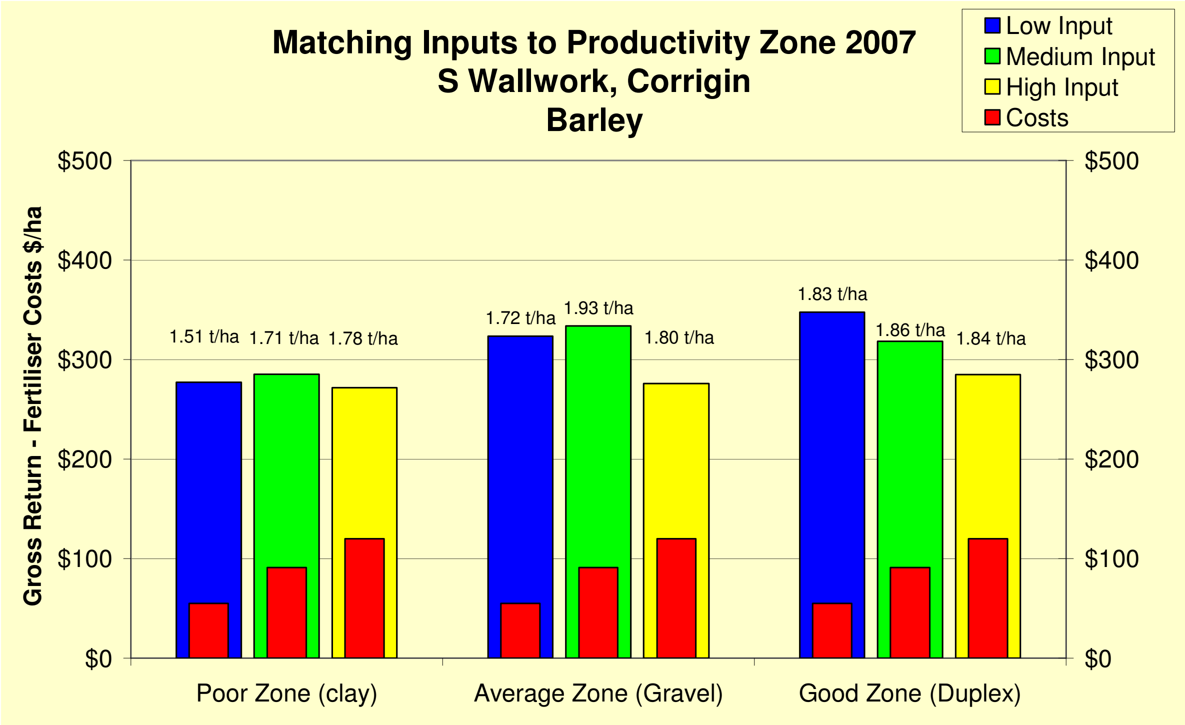

Figure 2. Economics of matching inputs to productivity zones


Figure 3. Photos showing germination in a good area of the poor zone (left) and average zone (right) July 2007.

Zone management vs. blanket treatment

Table 3 shows the economic ramifications of adopting variable rate technology to apply fertiliser inputs. The totals row shows the total paddock income if it was blanketed with low, medium or high inputs or treated with variable rates (low input on poor area, medium inputs on average and high inputs on good production zones).

The most profitable treatments for the paddock were the blanket application of low or medium inputs. The low input had nil applied fertiliser and it generated an extra $450 over the paddock compared to the medium input treatment. It was a low yielding season and the soil had strong nitrogen and phosphate levels so it is not completely surprising that the lower fertiliser treatments were more profitable.

The high input treatment was the highest risk, outlaying $60/ha on fertiliser and receiving no yield response and even lower economic returns. This treatment returned over $4,000 less than a blanket treatment of low or medium fertiliser.

The variable rate approach to fertilising the paddock resulted in a paddock return of $2,000-$1,500 less than a blanket application of nil fertiliser (low input) or the medium input treatment.

Table 3. Cost or benefit of matching fertiliser inputs to productivity zones

	Ha	Low	Medium	High	VRT
Poor	32	8 850	9 100	8 700	8 850
Average	41	13 250	13 650	11 300	13 650
Good	38	13 200	12 100	10 800	10 800
Total	**111**	**35 300**	**34 857**	**30 800**	**33 300**
Difference from medium input		**$450**	**$0**	**-$4100**	**- $1550**

CONCLUSION

2007 was a dry season at east Corrigin and crops failed to achieve maximum potential.

The site proved unresponsive to fertiliser, with treatments of low fertiliser input generating the greatest returns.

The most profitable way to fertilise the paddock was with a blanket application of low or medium inputs. The high inputs and variable rate treatments generated the lowest paddock returns.

The trial was repeated in 2006 and 2007 with low medium and high inputs repeated on the same sites.

These results are consistent with our previous findings in over 6 trials undertaken in low and high yielding seasons.

APPENDIX

TO RIP OR NOT TO RIP. WHEN DOES IT PAY?

Imma Farre, Bill Bowden and Stephen Davies
Department of Agriculture and Food Western Australia

Key Messages

On average removing subsoil constraints, such as traffic pans, gives positive grain yield responses, however, negative responses to ripping have been observed on some soils in some seasons. Sand plain soils are more responsive to subsoil constraint amelioration but the frequency of negative responses to amelioration is greater when only a mild constraint is removed. Negative responses on heavy soils are less likely but the size of the responses is also smaller making it only worthwhile removing the most severe constraints. Knowing the frequency and size of positive and negative responses to amelioration of subsoil constraints will allow farmers to determine whether it is worthwhile taking the risk to overcome the constraints.

Aims

Subsoil constraints to root growth can cause water and nutrient limitations to grain yields in our environment. The impact of subsoil constraints on crop growth and grain yield varies markedly with season, location and soil type. Both positive and negative grain yield responses to subsoil amelioration practices such as deep ripping and subsoil liming have been observed. To determine if amelioration of such constraints is a paying proposition, growers need to know the size and frequency of positive and negative grain yield, and dollar, responses to removing them.

It is impossible to collect enough direct, field trial information to handle the interactions of soil type and season on such responses. However, the validated crop simulation model APSIM-Wheat (version 4.1) can be run for a range of soil types, seasons and locations and so allow us to map the regions according to the chances of getting a response to amelioration. In the preliminary study reported here we specifically investigated the effect on wheat production, of reducing root growth rates in the 20-40 cm depth layer for four different severities of soil constraint at two locations and on two contrasting soil types.

Method

APSIM-Wheat (v. 4.1) simulates daily values of root growth, biomass and grain yield based on information on daily weather, soil type and crop management.

Simulations were run for Mingenew in the medium rainfall zone (mean April to October rain 350 mm) and Mullewa in the low rainfall zone (mean April to October rain 270 mm). Two soil types present in the wheatbelt of WA, a loamy sand (sand plain) and a duplex (heavy) soil were chosen. Simulations were performed for the 50 year period of 1957-2006. Soil was assumed to be dry at 1 January each year. Sowing time was controlled by a rainfall driven sowing rule, allowing sowing to occur on the first sowing opportunity between 25 April and 31 July.

These runs were devised to improve our understanding of the nature of the season by soil type by location responses to degrees of an unspecified root growth constraint between 20 and 40 cm deep in the profile. Roots had no constraints to growth above and below those depths – i.e. the constraint was a “pan” or “choke” of varying degrees of severity. In the model, this is done by changing the soil hospitality factor to simulate unconstrained, mild, moderate and severe levels of root constraints respectively. The severe level effectively stops roots penetrating more than 23 cm into the soil. The other levels allow roots to penetrate to different depths for different constraints, depending on season.

Results and Discussion

Yields

The results showed that removing any of the levels of constraint gave increases in the **average** yield across 50 years (Table 1).

Table 1. Average wheat yields (kg/ha) at different levels of a constraint to root growth in the 20-40 cm layer, for heavy and sand plain soil types at Mullewa and Mingenew.

		mean crop yields, 1957-2006			
		level of constraint			
Location	**Soil type**	**none**	**mild**	**moderate**	**severe**
Mullewa	heavy	1675	1613	1379	1104
Mullewa	sand plain	2515	2242	1008	573
Mingenew	heavy	2469	2299	1870	1557
Mingenew	sand plain	3375	2703	1279	771

It is interesting to note the average yields which are possible when roots are constrained to only about 230 mm of soil depth (severe constraint; Tables 1 and 2). On the heavy soil, some seasons allow yields of up to 2.5 t/ha with only 23 cm soil depth while on the sand plain soil, this limit is only about half that (Figure 1.), reflecting the relative storage of water in the two soil types. When there is no constraint to root growth this soil type effect is reversed.

Table 2. Average root depths (mm) at different levels of a constraint to root growth in the 20-40 cm layer, for heavy and sand plain soil types at Mullewa and Mingenew.

		mean rooting depth, 1957-2006			
		level of constraint			
Location	**Soil type**	**none**	**mild**	**moderate**	**severe**
Mullewa	heavy	908	843	699	233
Mullewa	sand plain	1666	1554	874	231
Mingenew	heavy	1023	957	699	233
Mingenew	sand plain	1833	1700	971	235

At the unconstrained and mild levels of constraint, root depth varied markedly with season but averaged 900 mm on the heavy soil and about 1700 mm on the sandplain soils (Table 2). At the moderate level of constraint these came back to about 650 mm and 900 mm respectively. At the severe level, no roots went beyond about 240 mm in any season (Table 2). Average root depths were of the order of 100-150 mm deeper at Mingenew than Mullewa – probably reflecting differences in average wetting depths.

The removal of the low level of constraint gave negative grain yield responses in a number of years (points above the 1:1 line in Fig 1.), indicating that in some years, a level of root constraint was beneficial. Practices like ripping a hardpan often gave negative responses even though in the long term the net effect was positive (Table 1). Invariably the negative responses were related to better early growth of the unconstrained crop leading to the squandering of water such that there were inadequate supplies to fill the grain later in the season.

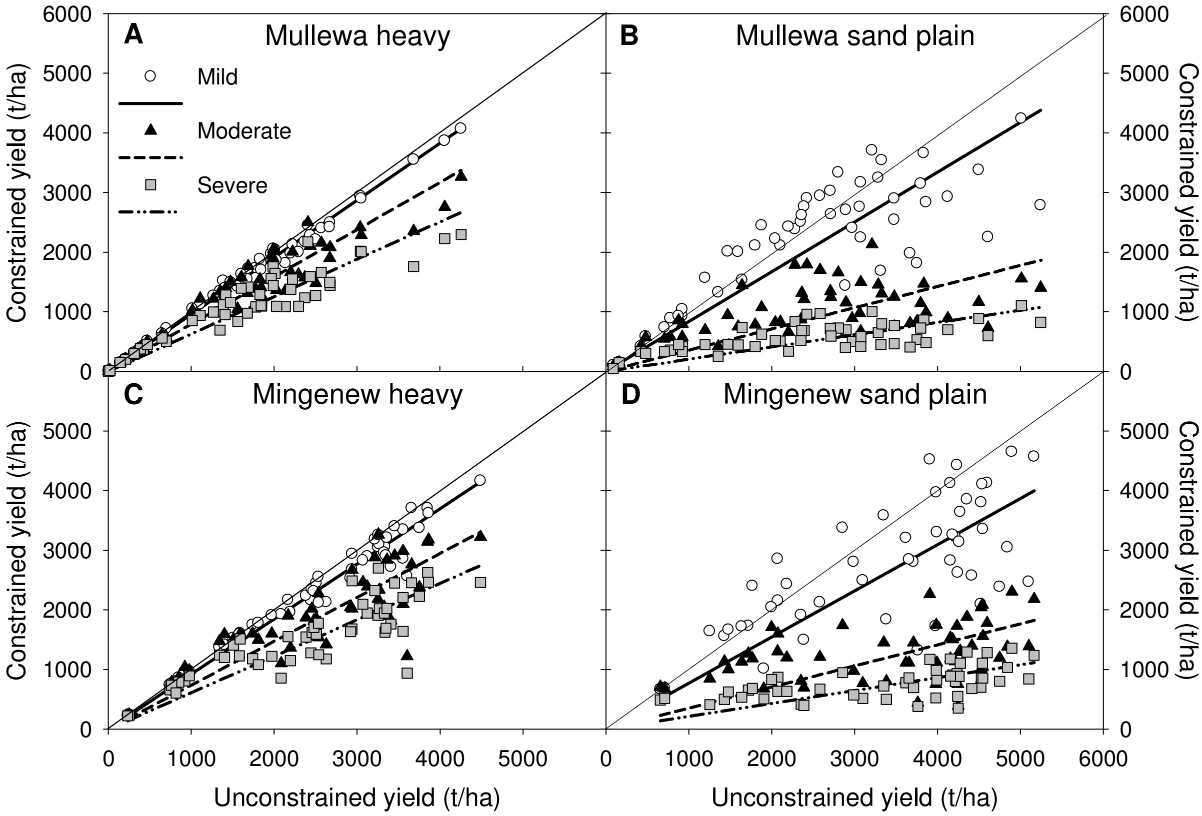

Figure 1. The effect of a mild, moderate or severe subsoil constraint on grain yield relative to the unconstrained yield for heavy (A,C) and sand plain (B,D) soils at Mullewa (A,B) and Mingenew (C,D).

The results showed differences between rainfall locations, soil types and season types. The removal of mild soil constraints gave a negative yield response in about half of the years in Mullewa and in one quarter of the years in Mingenew (points above the 1:1 line in Fig 1. or 100 minus the values in Table 3). In terms of soil types, responses were far greater on sand plain soils than on heavy soils. The negative responses to amelioration were more frequent on sand plain soils than on heavy soils (Table 3; Fig. 1). There was also an important effect of season type. Dry years or years with annual rainfall below median were four times more likely to have negative responses to amelioration than wet years (Table 3). The negative responses to the removal of constraints were more likely in low rainfall locations, on sand plain soils and dry years. Conversely, the frequency of positive responses to amelioration was higher in wetter years and at the wetter locations (Table 3). Heavy soils had more frequent positive responses than sand plain soils.

Table 3. Proportion of years (%) with a positive yield response to removing a mild subsoil constraint, for all seasons, dry (below median rainfall) and wet (above median rainfall) for heavy and sand plain soils at Mullewa and Mingenew.

Location	Soil Type	all seasons	dry seasons	wet seasons
Mullewa	Heavy	53	33	71
Mullewa	Sand plain	47	33	58
Mingenew	Heavy	73	50	96
Mingenew	Sand plain	69	50	88

Economics

In order to determine if it is economically viable to remove the subsoil constraint, we need to know the magnitude of the positive or negative yield responses to removing the constraint (above). We then need to calculate costs of ameliorating the constraint and the price of the grain. For this exercise (Table 4, Fig. 2) we have assumed a cost of (unspecified) amelioration of $40/ha and a return of $250/t for the grain. We have NOT taken future returns (i.e. residual value of amelioration) into account.

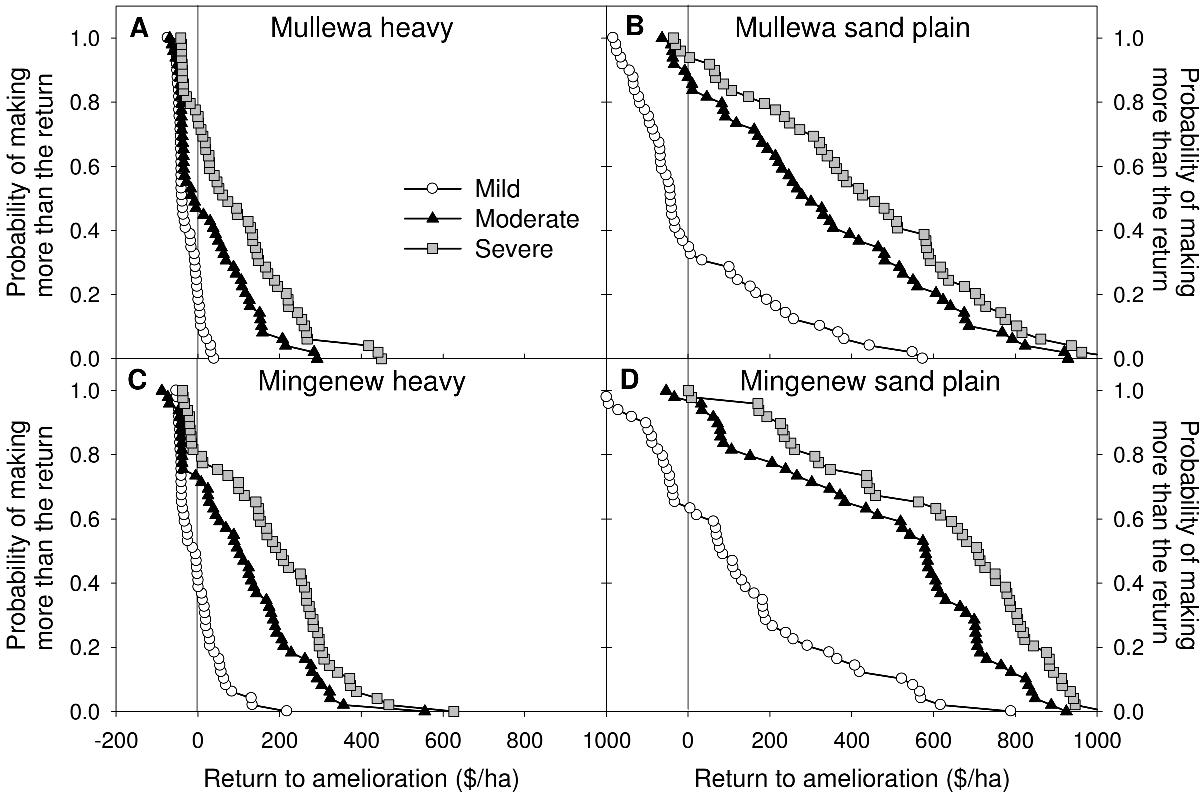

Figure 2. The probability of exceeding given levels of return to amelioration ($/ha) in the short-term (single season) from removing a mild, moderate or severe subsoil constraint for heavy (A,C) and sand plain (B,D) soils at Mullewa (A,B) and Mingenew (C,D).

The need to be able to define the severity of the constraint is obvious (Fig. 2). On heavy soils, the chances of getting significant, paying, short term, responses to amelioration of a mild constraint are small. On sand plain soils, it is obvious that that you will get paying responses to ameliorating moderate and severe levels of constraint in almost all seasons at both locations. At the mild level of constraint you very often get negative returns from amelioration. There is nothing like a destroyed promise of good returns (early crop growth is good in these situations) to turn a grower away from what is a long term, on average, paying proposition!

The marked variation of profitability of amelioration with season (as reflected in the shallowness of the curves in Fig. 2) suggests that we might get better returns to amelioration if we could predict/guess the nature of the season to come. An ex-post analysis of these runs (Table 4) shows that positive returns to amelioration on soils of mild constraint are far more likely in wet (and/or high yielding – Fig. 1) years than in dry years. The difference in probability of response between seasons diminishes markedly as the severity of the constraint increases.

Table 4. Proportion of years (%) with a positive net return from a removing a mild subsoil constraint, for all seasons, dry (below median rainfall) and wet (above median rainfall) for heavy and sand plain soils at Mullewa and Mingenew.

Location	Soil Type	all seasons	dry seasons	wet seasons
Mullewa	Heavy	20	8	29
Mullewa	Sand plain	35	13	54
Mingenew	Heavy	41	17	63
Mingenew	Sand plain	63	42	83

Note that compared with Table 3 yield data, the probability of getting positive returns is now higher for the sand plain soil than for the heavy soil - because the levels of response are a lot higher (pay more) on sand plain soils (even though they are less frequent).

Conclusion

From the current study it is clear that in most circumstances it is worthwhile removing subsoil constraints on sand plain soils (traffic and acid pans) regardless of their severity at Mingenew. Even in a lower rainfall zone like Mullewa it is well worth ameliorating moderate and severe constraints but for mild constraints there can be a negative effect in a significant number of years. Regardless of soil type or location the more severe the constraint, the bigger is the response to removing it. This fits with current deep ripping practices in the Mingenew area where sand plain soils are often deep ripped before each wheat crop in the rotation.

Amelioration of anything but severe subsoil constraints on heavy soil is probably not worth the effort (less than 500 kg/ha response in most years) until you come into higher rainfall zones. Severe constraints would be those that restrict root growth to such an extent that roots are unable to grow beyond 20-30 cm. In the field, constraints this severe should be quite obvious to direct observation of roots or to the presence of subsoil moisture below 30 cm after crop harvest. Overall, constraints have a far smaller effect on heavy soils than on sand plain soils. The higher water holding capacity of the heavier textured surface soils and the fact that for a given rainfall, the wetting front is far shallower means that a constraint on root growth to depth denies far less resources (water and nitrogen) to crops on heavy soils than on sand plain soils.

These findings have important implications for farmers and the research community. The farmers need to know the frequency and size of positive and negative responses to be able to determine if it is worth trying to overcome the constraints. To this end the GRDC funded WA subsoil constraints project (UWA00081) plans to map the agricultural areas of WA according to some of the above measures of response and chances of response to amelioration of subsoil constraints. The researchers and advisors need to be able to diagnose not only whether there are subsoil constraints but also how severe they are. This may be relatively easy for severe constraint which stops root growth completely but it is much more difficult to distinguish between moderate and mild constraints. The response to removing the constraint can vary markedly with season, location and soil type. Once the risks are defined it may be possible to adjust agronomic management practices (lower seeding rates and/or nutrient inputs, wider rows, etc.) to minimise the risk of a negative responses.

Key words

Subsoil constraints, amelioration, season, sand plain, heavy soils, location.

acknowledgments

This research has been funded by the Grains Research and Development Corporation SIP08, subsoil constraints initiative.

Project No.: UWA00081

Paper reviewed by: Mike Robertson