Sowing the seeds of success with PA

by Matt McCallum, McCallum Agribusiness Consulting and Phil Price, Mackellar Consulting Group P/L

For most Australian grain growers the adoption of guidance, autosteer and auto-boom shut-off technology has been a relatively simple process and the economic returns are easy to measure and start from day one.

Taking PA to the next step using VRA can potentially be financially rewarding, but investment will not yield returns if growers don’t have the basics right first. The following questions are important to consider and address before investing in VRA:

**Are my crop yields variable enough to warrant VRA of inputs?**

Findings from the Grains Research and Development Corporation (GRDC)-funded PA research indicates that unless there is at least a 1 t/ha difference in yield between high-yielding and low-yielding zones in a paddock (1.5 t/ha in WA), then paddock zoning and VRA is unlikely to provide a reasonable return on investment. There are probably more important things growers with low in-paddock yield variability can do with their time and money.

The scale of yield variability is also important to determine whether high-yielding or low-yielding areas are large enough to warrant VRA. Yield maps can provide this information.

**Is my whole-paddock agronomy sound enough?**

It is important the highest-yielding areas of the paddocks are achieving their water-limited yield potential before investing in VRA. The GRDC-funded research shows that more than 60% of paddock profit comes from maximising the water use efficiency (WUE) of the higher-yielding areas of the paddock.

If paddocks are underperforming because of factors such as weeds, inadequate across-paddock nutrition and disease, then VRA will not improve profitability compared with better basic agronomy.

**Do I know what is causing variability and can I easily manage these causes?**

If you know what is causing yield variability and it can be easily rectified — great.

Prime examples of such factors are soil acidity and sodicity. Variable rate lime and gypsum has been a success story in many cropping regions of southern Australia. Savings in the order of 15–35% across a paddock are common because inputs are applied only where they are needed. Mapping the pH of a paddock was a laborious task in the past, but new technology is making it far easier and more cost-effective.

Another example of where yield variability is well understood and managed is in the Mallee regions of Victoria and South Australia, where underperforming sandhills of the...
past are now reaching their water-limited potential through the combination of no-till cropping, better weed control and higher nutrition — particularly nitrogen and sulphur.

**Are the causes of variability not well understood, but consistent across seasons?**

You might not completely understand why areas are consistently low yielding, but they often can be managed anyway if they are consistent across years.

An example is subtle soil constraints (for example, subsoil sodicity, soil texture) in areas of paddocks where crops consistently yield 1t/ha lower than other areas over time.

These consistently poorer-performing areas may have an excess build-up of phosphorus in the soil due to less removal through grain, and fertiliser inputs can reduced in these areas without compromising yield potential.

**Are the causes of variability understood but not be easily managed?**

An example where yield variability is well understood, but difficult to manage is in soil zones with severe constraints (for example, very shallow soil, high toxicities), which can’t be ameliorated in a way that gives a significant return on investment.

In this case there is no point in wasting money trying to boost yields through VRA. If these areas consistently produce a negative gross margin (7 out of 10 years), then a better approach is to reduce inputs to a base level (seed only, no fertiliser and minimal herbicides) to reduce financial losses. Another approach could be to retire these poor-performing areas from cropping altogether and consider permanent pasture, agroforestry or biodiversity plantings for some alternative financial gain.

**Technology improvements:** Testing pH across the paddock used to be a laborious task, but in-paddock testing is now easy and time-efficient. PHOTO: TM NEALE

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**What about paddock zones that ‘flip-flop’?**

As many growers who have invested in VRA, such as Roger Lange on page 76, can attest, paddock zones that ‘flip-flop’ in performance across years are by far the most difficult to manage with VRA.

The major cause of flip-flopping yields is differences in growing season rainfall (GSR) — both when and how much rain arrives and in what quantities (for example, 70% large falls >10mm vs many small events <10mm).

The key issue is often how deep in the soil profile crops must draw water from. Often poor-performing areas of the paddock have barriers to root growth and function in their deeper layers or have low plant available water capacity (PAWC).

In years when crops grow mainly on frequently-replenished moisture in the upper levels they can perform well, but when crops need to use water from below 30cm, they perform poorly. Some growers who understand this (for example, from using NDVI/harvest index maps), are now using VRA successfully even where zones flip-flop.

**On-farm experience**

In this section growers share their experience with how they have improved their profits through strategic VRA, by reducing inputs in poor-performing zones and/or increasing inputs where required to maximise the performance of higher-yielding zones.

“Getting a better return for your dollar” is a common phrase growers use when talking about the benefits of VRA.

Excitingly, the following chapter also includes both trial results and on-farm experience of using VRA seed in the battle against annual ryegrass — an issue for every grain grower across southern Australia.

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**about the authors**

Both Matt McCallum and Phil Price have been involved in numerous GRDC-funded PA projects that have assessed the economic viability of VRA throughout the cropping regions of southern Australia.

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**for more information**

For more information on VRA go to: www.spaa.com.au and search under the ‘Resources’ tab for the latest information and links.
Mapping drives successful variable rate application

Adam O’Brien and his family Bill, Kevin and Damien, Ultima, Victoria achieved costing savings in the order of $15 per hectare in the first year of using variable rate sowing and fertiliser applications.

Across their 4000ha mixed cropping operation these savings amounted to $60,000, which paid for the initial capital outlay on their VRA system, with $30,000 left over for additional operating expenses. Adam O’Brien believes VRA has given his family confidence around applying fertiliser.

“Variable rate technology is an ideal tool to manage production risk on our higher potential soils and financial or cost risk on our less reliable soils,” Adam said.

During 2009, after investigating the benefits of VRA with their peers at crop walks and discussion groups, the O’Briens decided to invest in a VRA system.

Double strength: Retrofitting variable rate capacity to their existing two-bin flexicoil sowing rig has allowed the O’Brien family to manage VRA of phosphorus and nitrogen at sowing.
They retrofitted their existing two-bin flexicoil box to work as a variable rate seeder for a total cost, including wiring and screen (Viper), of $25,000. The O’Brien’s farm consultant from Dodgshun Medlin developed zone maps for their farm using four remotely-sensed data layers (see Figure 1) for a total cost of $6400 (about $1.60/ha), which included application maps.

**Extending the program**

After a couple of years of trial and error, the O’Brien family is comfortable with their nitrogen and phosphorus strategy for various soil types.

The amount of phosphorus fertiliser applied is relative to yield produced the previous year and the long-term yield potential of each soil type. A 27:12 blend is used up front to vary nitrogen and phosphorus fertiliser across soil types.

“We also like to plan our top-dressing program well ahead of the season,” Adam explained.

“Any soil types that are low in nitrogen, but with potential, are top-dressing priorities. Like most things we do on the farm, it’s about having a good operational plan.”

Deep soil nitrogen tests and an NDVI map of the whole farm in early spring have allowed Adam and his consultant Matt Witney to target paddocks for more nitrogen fertiliser.

Adam found the farm NDVI to be really helpful as it allowed him to question why some paddocks were higher in biomass than others. “It’s sort of like a pseudo yield map,” Adam said.

“We receive the NDVI as a laminated map and also as a KML file, which we auto extract into Google Earth, which allows us to easily zoom into paddocks.”

**Looking forward**

The O’Briens’ future PA plans are to invest in a variable rate spreader and/or a triple bin for the airseeder.

“The spreader would allow us to better target nitrogen during the season and the triple bin would enable us to manage the phosphorous separately to nitrogen at sowing,” Adam explained.

“Harvest yield maps could be used as phosphorus replacement maps, and nitrogen fertiliser applied according to soil type.”

“Currently, we waste some nitrogen fertiliser using the 27:12 blend because low-yielding soil types rarely need extra nitrogen.”

**Technical support:** Adam O’Brien works closely with Dodgshun Medlin consultants Matt Witney and Rick Rundell-Gordon (pictured) to develop zone maps that support a tailored fertiliser program.

**Adam O’Brien**

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**Figure 1. Zone map created from four data layers (elevation, Landsat surface, five dry year NDVI, gamma) on left correlates well with yield (right).**

<table>
<thead>
<tr>
<th>Yield Range (t/ha)</th>
<th>Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.2 – 3.4</td>
<td>10.12</td>
</tr>
<tr>
<td>3.0 – 3.1</td>
<td>7.97</td>
</tr>
<tr>
<td>2.7 – 2.9</td>
<td>21.74</td>
</tr>
<tr>
<td>2.5 – 2.6</td>
<td>12.54</td>
</tr>
<tr>
<td>2.0 – 2.4</td>
<td>12.11</td>
</tr>
<tr>
<td>0.0 – 1.9</td>
<td>6.88</td>
</tr>
</tbody>
</table>
Variable rate technology boosts efficiency and profit

Better control over crop nutrition and weed management, through PA, has boosted water use efficiencies (WUE) and farm profits for Mark Branson, Stockport, South Australia.

The main PA application Mark uses is VRA of fertiliser, focusing on the key nutrients: phosphorus and nitrogen. At harvest, Mark’s Case 7120 header is equipped with an AFS Pro 600 yield monitor, which generates a yield map for each paddock.

Using these maps, Mark converts the data into phosphorus replacement maps to vary fertiliser rates at sowing by simply plugging data into the Topcon X20 variable rate controller.

Mark uses a Horwood Bagshaw airseeder with electric drive and he has installed a Topcon X20 controller in his John Deere 8200 tractor and Miller Nitro 3275 sprayer, which controls the variable rate seed and fertiliser.

The tractor and sprayer are also equipped with autosteer and a RTK GPS guidance system with 2cm accuracy, which allows for controlled traffic and inter-row sowing.
Immediate benefits

During 2006, Mark started sowing with variable rates of fertiliser with almost immediate economic benefits.

“In the dry years from 2007–2009, I reduced phosphorus rates and only applied fertiliser where it was required, based on the previous season’s yield maps.” Mark explained.

Mark estimates since making the change to variable rate fertiliser he has reduced his overall fertiliser bill by a significant $36 per hectare.

“Phosphorus rates at sowing vary between 50–80kg/ha of MAP on the low-yielding paddocks and 80–120kg/ha of MAP on the high-yielding paddocks,” Mark said.

Nitrogen management

From 2002 to 2007 Mark used EM maps for each paddock, which demonstrated the variability of his soils, and explained one reason for large differences in available nitrogen.

“In one paddock, the available nitrogen varied from 118 units down to 15 units, which highlights the potential wastage in using blanket nitrogen applications,” Mark said.

With the purchase of a Miller Nitro 3275 self-propelled sprayer during 2010, Mark has also made a switch to applying variable rate liquid nitrogen.

Mark is also using the Topcon CropSpec™ sensors for variable rate nitrogen, which varies nitrogen according to the biomass of the crop. This is providing a significant part of the annual savings on the nitrogen fertiliser bill.

“We use PA for VRA nitrogen in different management zones in paddocks to better match inputs on the low-yielding areas with soil constraints, for example rocky hilltops,” Mark explained.

“In these low-performing areas we generally apply a low rate of 50kg/ha of MAP only and in extreme dry conditions no nitrogen and phosphorus, choosing to concentrate on the high-performing areas.”

Mark also bases VRA on soil types, for example he has areas of red clay, which can have poor crop establishment. Mark applies increased rates of liquid nitrogen in these areas at early tillering to encourage maximum growth and even up crop yields.

“The rates of nitrogen applied depend on how well the crop has established but generally range from 40–120/l/ha of UAN,” Mark said.

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Fingertip control: Mark Branson, Stockport, SA has installed a Topcon X20 controller in his Miller Nitro 3275 sprayer to allow him to apply variable fertiliser rates.
Variable sowing rates reduce ryegrass populations

Two SPAA trials have proven that variable sowing rates can reduce ryegrass numbers in problem areas within paddocks by up to 30%.

These results suggest that sowing rates could be a cost-effective option for growers who have weedy patches that are proving hard to control.

**Kybunga, South Australia (2007)**

Table 1 shows the results from the variable rate sowing trial on Robert Dalls’ farm near Kybunga, SA during 2007.

**Clare, South Australia (2010)**

Table 2 shows the results from the variable rate sowing trial on Craig Jaeschke’s farm near Clare, SA during 2007.

**Summary**

In both studies ryegrass seed production was reduced by 25–30%. According to PA consultant and researcher Sam Trangove, it is feasible to use variable sowing rates to help manage ryegrass. Sam’s research identifies that problem areas of ryegrass are quite stable within paddocks.

Increasing sowing rates by 50–70kg/ha in bad ryegrass patches is a cost-effective ($11-16/ha) method of reducing weed seed set.

“Numerous studies on the effect of crop competition on annual ryegrass conclude that more competitive crops will reduce ryegrass biomass and seed production,” Sam said.

“These trial results show how this principle can be applied in a site-specific way.”

“Most growers would agree there are no silver bullets when it comes to ryegrass management, and a variety of management strategies is required to manage ryegrass effectively.”

“This is particularly the case when dealing with a large weed population. Increased competition through increasing sowing rates contributes to control, but is not a means to the end on its own.”

“The evidence also suggests that ryegrass patches are most prevalent where crop vigour is less and therefore crop competition is reduced, but these areas do not always correlate with being lower yielding, due to soil water use and crop canopy interactions.”

**Stable issue:** Increasing sowing rates in weedy areas can reduce ryegrass density. The image above shows a bad ryegrass patch in a barley crop in western Victoria. Ryegrass tiller numbers were up to 745 tillers/m². PHOTO: ANDREW WHITLOCK
The reasons for reduced vigour in these patchy areas are many, including salinity, sodicity, poor nutrition, soil type, and water logging. Correcting the underlying cause of the lack of crop vigour may improve competition with ryegrass and reduce the ryegrass population, but in the absence of correcting the soil, manipulating crop competition by other means is a good starting point.

<table>
<thead>
<tr>
<th>Table 1. Plant count results, Kybunga SA (2007)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
</tr>
<tr>
<td>Seed rate (kg/ha)</td>
</tr>
<tr>
<td>--------------</td>
</tr>
<tr>
<td>110</td>
</tr>
<tr>
<td>140</td>
</tr>
<tr>
<td>180</td>
</tr>
</tbody>
</table>

Counts taken on 3 September 2007 and 5 November 2007

Accurate maps

“The key to success with variable rate sowing to manage weeds is to develop an accurate weed map of your paddocks,” Sam said.

“A combination of yield maps, soil maps, growers’ knowledge and in-crop scanning equipment can all help when developing weed maps.”

“Most importantly, weed maps need to be ground-truthed by driving or walking across paddocks.”

“When your weed map is defined it is then a matter of creating a sowing rate application map for the seed rate controller.”

Patch management

According to Sam, results from a wider study on patch management of ryegrass showed that using a high-efficacy herbicide treatment in a high-density ryegrass patch increased the grower’s return in the year of application. However, due to the large weed seedbank associated with these high-density ryegrass patches the second-year and third-year benefits were limited due to seed carryover from years prior to the herbicide application.

“For long-term patch management to be successful growers need to keep attacking the patches and preventing them from blowing out year after year,” Sam advised.

The full report can be downloaded from: www.spaa.com.au
Ryegrass struggles under targeted approach

Daniel Adams, Cockaleechie, Lower Eyre Peninsula, South Australia, considers annual ryegrass to be the biggest threat to his family’s business of continuous cropping.

The Adams family has employed many ryegrass control strategies over the years including baling straw from the header, increased sowing rates, using a wide variety of herbicides and mixtures, burning, crop topping legumes and wheat, and weed wiping lentils.

“Break crops such as canola and legumes have provided our best ryegrass control in the past, but we are fast running out of selective herbicide options for these crops,” Daniel said.

This has lead Daniel to investigate the use of PA to help in the battle against ryegrass.

For the past two years the Adams have added variable rate sowing and spraying to their ryegrass control arsenal in zones within paddocks.

The first step in the process was to generate accurate weed maps. High-density ryegrass patches on their farm are generally located in lower-yielding areas of paddocks subject to periodic waterlogging.

Daniel has simply converted yield maps into an image that can then be used to vary the rate of seed and herbicide (see Figure 1).

Topcon X20 units are then used to increase the sowing rate by 20–40% in high-density ryegrass patches and the John Deere GS2 is used to increase the pre-emergent spray rates by 10–25%.

Measuring success

Without carrying out weed counts Daniel says it is hard to measure exactly how successful their patch management program has been, although he feels it has helped keep ryegrass numbers at manageable levels to facilitate continuous cropping.

“We are looking to PA to help maximise production off every hectare across the farm to remain viable,” Daniel said.

As part of his PA program, Daniel has been investing in VRA phosphorus for the past three years, soil testing zones within paddocks based on soil type.
Ryegrass approaches yield varied results

Ryegrass management can take many forms and as research carried out by the Western Australian Herbicide Resistance Initiative (WAHRI) revealed, these varied approaches can have differing levels of success. Efficacy of many of these practices can vary, not just season-to-season but paddock-to-paddock and crop-to-crop. Table 1 provides a guide to what can be expected when employing these practices, in terms of what is typical and the range of possible results.

Table 1. Expected results of various ryegrass management practices

<table>
<thead>
<tr>
<th>Control practice</th>
<th>Control of ryegrass weed seeds or plants (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Most likely</td>
</tr>
<tr>
<td>Shallow 'tickle' cultivation*</td>
<td>35</td>
</tr>
<tr>
<td>Stubble burning</td>
<td>40</td>
</tr>
<tr>
<td>High crop sowing rate</td>
<td>40</td>
</tr>
<tr>
<td>Delayed sowing (~ three weeks, then apply knockdown)</td>
<td>50</td>
</tr>
<tr>
<td>Hay cutting**</td>
<td>80</td>
</tr>
<tr>
<td>Green/brown manuring</td>
<td>98</td>
</tr>
<tr>
<td>Spraytopping (crop topping — paraquat)</td>
<td>70</td>
</tr>
<tr>
<td>Grazing</td>
<td>70</td>
</tr>
<tr>
<td>Seed catching</td>
<td>60</td>
</tr>
<tr>
<td>Crop suppression of weed seed production</td>
<td>Most competitive to least competitive</td>
</tr>
<tr>
<td></td>
<td>barley &gt; wheat &gt; canola &gt; lupins</td>
</tr>
</tbody>
</table>

Range refers to a usual range of outcomes, there will be some cases where % control is beyond this range.

* Control % for this practice presented as a reduction on in-crop weed numbers. Control % for all other practices presented as a reduction or removal of total weed seed set

**Control can be up to 95% when followed up with spray to prevent ryegrass regrowth.

Values derived from a range of published and unpublished trial data, expert opinion and assessments by growers.

Source: WAHRI, 2003, now Australian Herbicide Resistance Initiative (AHRI)
Input costs drive variable rate approach

A run of poor years from 2002 to 2008 and a massive increase in fertiliser prices at the end of 2007 was the impetus for Roger Lange, Appila, South Australia to adopt PA technologies.

Roger saw VRT as an opportunity to reduce costs without reducing yield potential and set out to prove this with trial strips across several paddocks on his farm.

“Reducing herbicide use was not really an option, which only left fertiliser, particularly phosphorus, as an alternative. Our soil testing indicated we had good phosphorus reserves in most areas so we decided to go for it,” Roger said.

Trial strips of di-ammonium phosphate (DAP) fertiliser at rates of 0, 30 and 60kg/ha have been in place for the past four years and have proven that reducing phosphorus rates down from a historical application rate of 60kg/ha has had little impact on yield and profitability (see Table 1).

Typically, the yield response from adding phosphorus has been in the order of 0.1–0.2t/ha for cereals across the years and paddocks.

Having the confidence to reduce phosphorus rates, Roger then adopted a variable rate phosphorus program based on phosphorus replacement across the farm.

Roger simply converts yield maps to phosphorus replacement maps for the following year and 3.5kg of phosphorus per tonne of grain is replaced for cereals, 4.5kg of phosphorus for lentils and 7kg of phosphorus for canola.

For his VRA at sowing, Roger uses an Integra Insight, which controls the rate of fertiliser using linear actuators on his Simplicity air cart.

Table 1. Wheat yield in response to varying rates of phosphorus fertiliser

<table>
<thead>
<tr>
<th>DAP (kg/ha)</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2.52</td>
<td>3.21</td>
<td>1.18</td>
</tr>
<tr>
<td>30</td>
<td>2.79</td>
<td>3.46</td>
<td>1.19</td>
</tr>
<tr>
<td>60</td>
<td>2.70</td>
<td>3.44</td>
<td>1.18</td>
</tr>
</tbody>
</table>

On-farm trial results from Appila, South Australia, 2009-2011.
The whole system was pretty simple to set up and cost about $20,000,” Roger estimated. According to Roger’s calculations, he has recouped this cost within two years.

Roger’s set-up can be over-ridden if the electronics fail for some reason, and he can set rates manually and carry on sowing; something he considers very important with PA.

Roger has chosen not to zone his paddocks as yields tend not to be consistently stable across years and areas often “flip-flop” between high and low yields depending on the season (see Figure 1).

For Roger, PA needs to be practical, profitable and able to be over-ridden if things go wrong. Having gained confidence in his variable rate phosphorus program, the next step will be experimenting with variable rate nitrogen.

Strategic approach: Yield mapping is central to Roger’s VR phosphorus program in addition to measuring yield results from his on-farm trials.

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Increased profits come from input savings

For Neil Luehmann, Berriwillock, Victoria, the aim of precision agriculture is not to increase yields but to reduce costs and increase profit margins.

And by all accounts, he is achieving that goal — he used to apply 140 tonnes of fertiliser across the farm and now only uses 100t per year while maintaining yields.

Neil has been keeping yield maps from his harvester since 2003 and carrying out variable rate fertiliser applications, firstly at sowing and then later during the growing season, for the past six years.

“For the first four years, I did my own analysis, converting yield maps to fertiliser application maps,” Neil said.

“I now use an agronomist to do the analysis — he overlays the yield map with biomass and soil type. This helps to qualify the data as well as revealing areas of commonality between yield, biomass and soil type.”

“In some ways, I actually think it was better doing the maps myself — it’s not difficult and you learn a lot more about your paddocks.”

Neil currently uses seven fertiliser zones — top three, a flexible mid zone and bottom three.

Each zone receives a different rate of nitrogen. In an average year, most of the paddock will get the mid zone rate, but in a better than average year, most of the paddock will get a rate of a higher zone.

Profit driver: Precision agriculture has allowed Neil Luehmann to reduce input costs through variable rate fertiliser and herbicide application, boosting profit margins. PHOTO: CHRIS WARRICK
“The flexible mid zone moves to suit the year — in an average year the mid zone (in terms of application rate) is in the middle with three zones above and three below. In a high-moisture year, the mid zone will move up with only one or two zones above it and the rest below it.”

**Application approach**

During sowing Neil applies enough nitrogen to achieve a 1.5t/ha yield on better soils, based on the previous year’s yield map (this is the mid-zone application rate).

He also applies a base rate of phosphorus calculated to achieve a 2t/ha yield based on replacement for yields achieved by the previous year’s crop.

Neil uses liquid fertiliser to apply nutrients at sowing and says it is more work, but given he has a 5000L tank he only has to refill it once a day.

During the growing season, Neil uses an innovative approach to apply fertiliser — still using VRA, he uses two separate bins and two different strategies.

“I apply sulphate of ammonia based on soil type — the sandy soils get a higher rate than my heavier soils — and urea applications are based on last year’s yield map (at rates calculated to meet crop potential).

“This usually means applying enough nitrogen to feed a 0.5-1t/ha crop. Combined with the nitrogen applied at sowing there is enough nitrogen to achieve a yield of 2-2.5t/ha.

In addition to yield maps, Neil does in-paddock trials (these include a no-fertiliser treatment) as a gauge of when to top-dress and to check overall that fertiliser is benefitting yield.

**Labour saver**

It’s not only the reduction in costs that appeals to Neil, but he believes he has selected technology that also makes labour management easier — his machinery can practically drive itself.

“During 2006 I moved to EZ-steer from light bar guided steering and during 2007 I moved to 2cm autosteer across my seeder, harvester and sprayer,” Neil said.

“I don’t do CTF — I struggle to see the return on investment.”

Neil finds inter-row sowing (on 300mm spacings) is giving:

- Improved trash clearance
- Better seed to soil contact and seed placement
- Better soil structure
- Disease-free crops.

“*The biggest challenge during sowing is that different soils make the bar wander off course,*” Neil said.

**Targeted weed control**

In addition to investing in VRA for fertiliser inputs, Neil has also made a move into variable rate weed control.

“I used a contract WeedSeeker™ last year and while it cost an extra $3/ha, the saving on chemical paid for it,” he said.

“I delivered a blanket application of Roundup (glyphosate) and used the WeedSeeker to apply Garlon (triclopyr) and 2, 4-D ester to control summer weeds.”

Neil is not sure of his next move with PA.

“It’s hard to see where the next gain in saving input costs will be,” Neil said.

From Neil’s experience, you can cut costs too much. “A few years ago we cut our nitrogen and phosphorus back too much at sowing,” Neil said.

“As a result, with a dry start to the season, the crop was late getting going and just couldn’t catch up — in the end, yields suffered.”

“The lesson is that you can reduce your inputs too much, particularly at the start when crops need sufficient nutrients for early vigour.”

“Even on the poorer soils you still need to put on enough to get plants underway.”

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**Neil’s tips for newcomers to VRA can be summed up in three easy points:**

- You don’t need autosteer to implement VRA — there is no reason why you can’t use VRA on a manually steered machine. It comes down to working out what is your best return on investment.
- You don’t need yield maps to get started — you can buy aerial soil and biomass maps for about $4/ha
- Keep it simple!

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For South Australian Mallee grain grower, Mark Stoeckel, VRA is all about getting the best return for your fertiliser dollar by farming each soil type to its potential. And with an increase in gross margin of almost $30 using VRA fertiliser, it seems Mark could be onto something.

Like most Mallee grain growers, Mark has three major soil zones across his property — sandy rises have the highest yield potential but are generally low in nutrition, the midslopes also have significant yield potential, but are more fertile than the sandy rises. The heavy flats often have high to very high levels of nutrition, but have severe constraints that limit root growth and yield potential (for example, boron, high pH, salinity, sodicity and calcrete layers).

Keen to investigate the potential of VRA to address this soil variation Mark designed an on-farm replicated trial to test a range of fertiliser treatments (see Table 1).

Mark used information gathered during previous years, including EM38 soil data and physical and chemical soil tests carried out across the paddock to develop a paddock zone map using the ‘Your Soil’s Potential’ model (see Figure 1).

The trial results shown in Table 1 illustrate the potential for VRA fertiliser to increase gross margins by $29.72 per hectare.

Reaching your potential

The key to applying variable rates of fertiliser in the Mallee is summarised by PA consultant, Peter Treloar: "It’s not about trying to even up the yields across the paddock, it’s about recognising and understanding the variations in yield potential and applying the appropriate inputs to best allow that potential to be reached".

Peter believes it’s not always about applying more fertiliser, but rather redistributing inputs into the areas of greatest potential return. Increases in gross margins of $25–$30/ha from using variable fertiliser rates in the SA Mallee is common according to Peter.

**Farming to soil potential boosts returns**

**Trial information**

Farmer: Mark and Sue Stoeckel  
Location: Paringa-Murtho, South Australia  
Crop type: Wheat  
Sowing date: 8 May 2010  
Sowing rate: 45kg/ha  
Fertiliser rate: 45-60kg DAP/ha, 0-90kg Urea/ha

**Figure 1. ‘Your Soil’s Potential’ zones**

Orange/red areas are the swales with severe soil constraints and low yield potential. The blue areas are the dunes with the highest yield potential.
### Table 1. Impact of variable rate fertiliser application on yield

<table>
<thead>
<tr>
<th>Zone</th>
<th>Total area (ha)</th>
<th>Fertiliser rates (kg/ha)</th>
<th>Yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Flat rate</td>
<td>Variable</td>
<td>Flat rate</td>
</tr>
<tr>
<td></td>
<td>DAP Urea</td>
<td>DAP Urea</td>
<td>DAP Urea</td>
</tr>
<tr>
<td>Sandy rise</td>
<td>16</td>
<td>45 0</td>
<td>45 90</td>
</tr>
<tr>
<td>Midslope</td>
<td>98</td>
<td>45 0</td>
<td>60 0</td>
</tr>
<tr>
<td>Flat</td>
<td>23</td>
<td>45 0</td>
<td>0</td>
</tr>
</tbody>
</table>

Difference in grain yield across the paddock using VRA compared with flat rate: 19.394t
Difference in fertiliser use across the paddock between VRA and flat rate: 1.864t

If results are applied across the paddock, the variable rate approach would increase income by $4071.80 compared with a flat rate of fertiliser, giving a gross margin of $29.72/ha.

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Mapping the Mallee

The Mallee Sustainable Farming group (www.msfg.org.au) has been working with growers for a number of years to develop cost-effective methods of mapping soils for VRA of inputs.

Growers have widely adopted the highly successful ‘Your soil’s potential’ model to help them recognise the differences in yield potential across soil types. By using the model growers can realise the potential of VRA by adjusting inputs accordingly. This can be broken down into a three-stage process:

1. Determine soil types and measure or estimate their plant available water and nitrogen content. Initially growers can use a combination of their own knowledge, EM38 mapping, NDVI maps and strategic soil sampling.

2. Enter this information into a crop model such as the Mallee Calculator or Yield Prophet to determine inputs at the start of the season.

3. Adjust inputs mid-season according soil type, yield potential and seasonal conditions. Crop models and in-crop NDVI can be used at this stage of the season for top-up nitrogen decisions.

In the example outlined in Figure 1, no follow-up nitrogen would have been required to achieve average to above-average yields on the swale soil type, as opposed to the dune soil type, which needed extra nitrogen to maximise yield potential.

This outcome is likely to be fairly typical in most years in a Mallee environment.

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**Figure 1.** A Yield Prophet output, on two soil types on Mark Stoeckel’s Paringa property, 29 July 2010

**Soil type: Dune**
- Initial PAWC on 8 May: 22mm
- Initial nitrogen status on 8 May: 41kg/ha

**Soil type: Swale**
- Initial PAWC on 12 May: 26mm
- Initial nitrogen status on 12 May: 254kg/ha

Given existing nitrogen levels were not limiting yield, both yield outcomes are the same.
Much like the Mallee, the Upper South East of South Australia has quite distinct soil types with large variations in yield potential. Two SPAA trials were established during 2010 to demonstrate the benefits from variable rate fertiliser — particularly phosphorus (P). The first trial was carried out on Brad and Barry Williams’ property near Cooke Plains. Two soil types were identified in this trial (see Figure 1):

- **Red** — Low-fertility sandy rises, with low yield potential (0–2 t/ha average wheat yield)
- **Green** — Sandy loam over clay to heavy loam, with higher yield potential (2.0–3.5 t/ha).

Three rates of DAP were applied (26, 55, 83kg/ha) and nitrogen rates were constant at 15kg/ha.

The most rates of fertiliser that gave the best financial return were 55kg/ha on the sandy rises, and 83kg/ha on the sandy loam over clay to heavy loam (see Figure 2).

The hypothetical impact of acting on these trial results across the whole paddock, by applying a variable rate fertiliser program, would have yielded an increase in gross margin of $25/ha.

### Trial information

**Farmer:** Brad and Barry Williams  
**Location:** Cooke Plains, South Australia  
**Crop type:** Barley (Flagship™)  
**Sowing date:** 18 May 2010  
**Sowing rate:** 70kg/ha  
**Fertiliser rate:** DAP (26, 55, 83kg/ha), N 15kg/ha  
**2010 rainfall:** 507mm (2010 GSR): 317mm

### Figure 1. Soil types at Cooke Plains, SA, 2010

![Image of soil types at Cooke Plains](image1.png)

### Figure 2. Yield results for variable rate fertiliser applications, Cooke Plains, SA 2012

![Graph showing yield results](image2.png)

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The full report can be downloaded from:  
www.spaa.com.au
The second trial was on Neville and Celia Kernicks’ property near Coonalpyn in a paddock with three well-defined soil types (see Figure 3):

- **Red** — Low-fertility sandy rises, often referred to as ‘gutless white sand’, which have low yield potential (0–1t/ha average wheat yield)
- **Yellow** — Mid-slopes with loose limestone/rubble, which have higher yield potential (1–2t/ha)
- **Green** — Heavy, loamy sand over clay with limestone, which has the highest yield potential (2–3t/ha).

Fertiliser approach

Three rates of DAP (40, 60, 80kg/ha) were applied across the three zones.

The most rates of fertiliser that gave the best financial return were 40kg/ha on the sandy rises, 60kg/ha on the mid-slopes and 80kg/ha on the heavy loamy sand, which was as expected (see Figure 4).

The hypothetical impact of acting on these trial results across the whole paddock, by applying a variable rate fertiliser program would have yielded by an increase in gross margin of $16/ha.
Variable rate technology provides greater control

The dry years of 2006–08 provided the impetus Graeme Baldock, Buckleboo, South Australia needed to take his next step in PA — from a guidance-base spraying system to variable rate sowing and fertiliser application.

Graeme first entered the world of PA during 2002, investing in a KEE Zynx 10 guidance system, to guide his sprayer and reduce chemical overlap. Several years later he bought another KEE Zynx guidance and autosteer system to install in the sowing tractor for increased sowing accuracy.

But the real impetus for change came when Graeme bought a new John Deere 9650 header, which came equipped with a yield monitor.

Graeme started collecting yield mapping data from the 2004 harvest onwards but admits he really had little understanding of how to apply the information.

But during 2006–08, the application of blanket rates of fertiliser was proving expensive and nutrients were building up in areas where the crops were not using them.

During 2009, Graeme decided to make a switch to variable rate fertiliser and seed as he already had the Topcon controller, which incorporates the VRA program. Modifications costing about $20,000 to his Morris 7250 seeding cart ensured it had VRA capabilities.

Yields drive zones

Using his yield data, Graeme created zones on maps in the Topcon Maplink program and assigned values to different fertiliser rates in kilograms per hectare. Other layers, such as soil types, EM38 and ground-truthed maps, created with a GPS in the ute, were then incorporated to develop specific management zones and paddock maps for the DAP fertiliser program at sowing.

Generally, DAP rates vary from a high application of 80–90 kg/ha down to a rate of 20kg/ha on the poor-performing, heavier soils.

Graeme usually applies a baseline DAP rate of 50kg/ha, but inputs are planned around the replacement of nutrients taken out by the previous year’s crop.

These rates will vary depending on the season and outlook for the growing season.

Graeme aims to complete his fertiliser maps during April, before sowing, and estimates that it only takes about one day’s work to develop the maps.

Although, he admits that cleaning up the yield maps and checking for any discrepancies does take time.

All Graeme’s paddocks have soil type variability, so generally about one-third of the paddock will receive the blanket rate of about 50kg/ha, although this depends on seasonal conditions.

During 2012, Graeme plans to apply a more general blanket rate of fertiliser, with only about 15-20% getting added rates. This follows three good production years where yield has been more consistent across paddocks.

PHOTO: KYLIE NICHOLLS

Embracing technology: Graeme Baldock, Buckleboo, South Australia is embracing variable rate sowing, granular and liquid fertiliser applications as part of his mixed cropping operation.

PHOTO: KYLIE NICHOLLS
Ground-truthing

Ground-truthing the yield data is a vital part of Graeme’s map development, as he has the paddock knowledge to know if there are discrepancies in some of the yield maps or if information is missing. For example, there may have been frost in one area of the paddock, which affected the yield results.

During the past two years, Graeme has carried out deep soil nitrate tests in paddocks with high variability as part of the ground-truthing of data. He also plans to complete soil tests in the paddocks to check the phosphorus and trace element levels.

Technology upgrade

During 2010, Graeme decided to upgrade to a Morris 8370 air seeder cart to apply liquid nitrogen (as UAN). The cart is equipped with two granular fertiliser bins and one liquid fertiliser tank.

Graeme now has three VRA maps, one for liquid nitrogen, one for granular fertiliser and one for sowing rates.

Variable rate liquid nitrogen is applied at sowing, at rates varying from 20L/ha up to 55L/ha. Top-up rates of liquid nitrogen are applied throughout the growing season as required based on the seasonal outlook. The rates vary from 10L/ha to 30L/ha.

Graeme also varies his sowing rates, using a base rate of 50–55kg/ha, varying from a low of 40kg/ha up to 70-80kg/ha, depending on seasonal conditions.

On consistently non-performing areas about 20% less seed is sown, and Graeme is concerned less plants per square metre will result in increased weeds. In known high-density ryegrass areas, Graeme maintains a sowing rate above 55kg/ha to ensure sufficient crop competition.

Graeme also applies 2L/ha of zinc sulphate as a liquid along with the fungicide, Flutriafol, at a rate of 200ml/ha in the same brew. This approach works well according to Graeme, although he did experience some compatibility issues between the zinc sulphate and liquid nitrogen, which caused nozzle blockages. He now adds increased amounts of water to alleviate the problem.

On target:

Graeme develops specific zone management maps that allow him to target fertiliser rates at sowing, where they will have most impact on yield. PHOTO: KYLIE NICHOLLS

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Yield data:

Collecting yield data at harvest is helping Graeme Baldock develop a VRA fertiliser program that minimises costs while maintaining production. PHOTO: GRAEME BALDOCK

a guide to getting the best results
Incompatibility slows progress, but initiates innovation

Adding a variable rate controller to the seeder during 2011 helped Mark and Steve Day, Lockhart NSW take the logical next step into prescription farming. But it wasn’t a simple jump.

Compatibility issues caused largely by outdated components slowed their adoption of VRT. “Despite being mechanically capable of delivering variable rates, the Farmscan system on our seeder wasn’t compatible with the John Deere guidance software and it was simply outdated like any home computer,” Mark said.

“After two years of persistence, a few dollars and a bit of farmer-dealer innovation the issues are gradually being resolved.”

“We were able to apply variable rates of phosphorus by re-wiring the valves and sensors on the bins and adding a spray controller to the fertiliser bin. In this first year we wrote our prescription in litres per hectare because the spray rate controller only accepts this form of units.”

“But the end result was the same — the machine thinks it is a sprayer, except it is dispensing a dry product instead of a liquid.”

“We wanted to achieve an all-in-one system to control the existing hardware. At the end of the day having one screen to steer the tractor and implement, control the seeder and accept prescription maps was the end result, and makes for a clean cabin with one system that is easy to operate.”

Easy to operate: Mark (left) and Steve (right) have achieved their goal of an all-in-one system for their PA program. PHOTOS: FLEUR MULLER
Mark and Steve hope new John Deere hardware will mean all three bins on the air-seeder will deliver variable rates of seed and fertiliser this coming season.

The John Deere Apex program is used to analyse yield data and create variable rate phosphorus application maps as shape (shp) files. Starter fertiliser rates in a normal year will now vary from 35kg mono-ammonium phosphate (MAP) to 100kg in any given paddock.

Happy with the level of phosphorus stored in the soil — Colwell P levels range from 35–90 — Mark and Steven aim to maintain these levels using crop removal rates to determine phosphorus application rates. For every tonne of grain harvested they apply four kilograms of phosphorus.

Mark says the main savings from VRT are the result of reducing fertiliser around trees and tree lines, which never grow crop, or reducing the phosphorus soil bank where it has built up above critical levels.

**On-farm trials**

Adopting PA has also allowed Mark and Steve to carry out replicated on-farm trials to provide solid data on which to base their management decisions.

“After you have the system up and going, performing on-farm trials becomes very easy,” Mark said.

“In our last trial we achieved a randomised block design with four rates of fertiliser and three replications.”

“The seeder automatically made all the adjustments to create a statistically valid trial.”

**Fine-tuning with more data**

The brothers also used Trimble GreenSeeker™ crop sensors and NDVI satellite imagery over a small area to help fine tune in-crop nitrogen applications.

“We hope adding another layer of crop data during 2012 from NDVI satellite images and crop monitoring tools will guide future variable rate nitrogen applications,” Mark said.

Mark and Steve say data management and the ability to make profitable decisions from the information is one of the biggest limiting factors to adopting PA.

“The fundamentals of any farming system do not change whether you use PA or not. Good agronomic practices always come first and PA tools complement these decisions,” Mark said.

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