# CASE STUDY
## VARIABLE RATE LIME

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

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# PA for Profit: Show me the money

## Introduction

This is one of five case studies in the Profit First PA communication series derived from the GRDC funded project 'Assessing the economic value of precision agriculture tools for grain farming businesses in the Southern Region'. Other project outputs have included:

- a review of existing information on the economics of PA
- a management guideline to aid decision making for growers and advisers in adoption of PA
- a series of short videos, podcasts and fact sheets to further highlight the economics of PA when done well

Previous work has found substantial financial benefits are possible from variable rate (VR) lime savings (up to 30-75% Whitlock 2015). Similar work found savings of $16-73/ha were possible (RDP00013 2015). This case study compares the experiences of two growers who are utilising variable rate lime applications to capture their profit opportunity in addressing soil acidity.

The project has identified a 5-step process (Table 1) to make sound financial decisions when considering adoption of PA.

**TABLE 1 PROFIT FIRST PA QUESTIONS**

| FIVE PROFIT FIRST PA QUESTIONS |
|---|
| 1. What are the profit gain opportunities for the farm business using the profit driver's framework |
| 2. Does PA have a role in addressing those constraints/opportunities? |
| 3. What is the cost and benefit of implementing the PA practice as determined using a partial budget approach. |
| 4. Are there other benefits or barriers to consider? |
| 5. Does the business have the capacity to usefully implement the technology? |

The following table is a broad guide to where Variable Rate Lime is likely to have fit (questions 1 and 2).

**TABLE 2 AREAS OF LIKELY RESPONSE FOR VARIABLE RATE LIME**

| RAINFALL ZONE | SUBREGION | VR LIME FIT |
|---|---|---|
| LOW | Upper EP | |
| | Western EP | |
| | Upper North | |
| | SAVIC N Mallee | |
| | SAVIC S Mallee | |
| | Vic C Mallee | |
| MEDIUM | Lower EP | |
| | Central YP | |
| | Lower YP | |
| | NorthYP/Mid North | |
| | Wimmera-Bordertown | |
| | SA Upper SE | |
| | Central Vic | |
| | Nth Central Vic | |
| HIGH | SA Lower SE/KI | |
| | Southern Vic | |
| | NE Vic Slopes | |
| | Tas Grain | |

**Key:** Green = highly likely, yellow = sometimes likely, orange = unlikely

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This case study assumes that the profit opportunity has been correctly identified, and that PA is an appropriate way for the farm to tackle it (questions 1 and 2). We focus on answering the remaining three questions.

Details of each participant and their involvement in this survey are listed in Table 2. Several other growers were also interviewed but are not included in the economic analysis. Their insights form part of the background discussion.

Doing your own numbers is a critical part of the decision making process with PA. The examples shown here are not universal, and are intended only as examples of what is possible.

## QUESTION 3: What is the cost and benefit of implementing the PA practice as determined using a partial budget approach. (Do the economics stack up?)

### Financial benefits

**TABLE 3 BACKGROUND INFORMATION FOR CONTRIBUTING FARMS**

| | FARM 1 | FARM 2 |
|---|---|---|
| Location | NE Victoria | SW Victoria |
| Annual rainfall (mm) | 500 | 500 |
| Property size (ha) | 3500 | 2100 |
| Crop mix | Wheat 40%, Barley 25%, Canola 35% | Wheat 14%, Barley 10%, Canola 26%, Lupins 7%, Oaten Hay 5%, Pasture 38% |
| Participant description of farming system | Continuous cropping, controlled traffic farming with full stubble retention. | Highly intensive mixed operation with sheep, cattle and cropping. |
| Profit opportunity | Increase yields, reduce paddock variability, reduce ryegrass competition in acidic areas. pH varies from 4 – 6.5. | Reduce expenditure on maintenance lime applications, which were previously blanket applications. Increase land productivity. pH difference of 1 unit between most and least acidic areas. |
| PA Approach | Implement variable rate liming rather than a blanket lime approach. Invest in soil testing to map pH variability. | Using grid soil sampling to apply variable rate applications of maintenance lime within paddocks. |
| Assumptions on benefits | Spent $10,000 on soil maps to use VRT, previously would have spent $500 on basic soil tests. Detailed soil maps were used to look at Phosphorous variability as well, therefore it was assumed that $5,000 of the cost could be attributed to the variable rate lime case study.<br>Previously using a blanket lime maintenance application and now with variable rate is still using the same amount of lime. Therefore, the only profit benefit is from yield improvements and labour saving.<br>A benefit of 0.5t/ha in. wheat/barley yield and a 0.2t/ha in canola yield is estimated over 20% of the treated area.<br>A labour saving of 3 x 8-hour days at $30/hour. | A reduction of 0.95t/ha in the amount of lime required.<br>Labour cost saving on the contractor's fee of $9/ha as less lime was spread enabling a cheaper rate. |
| PA Skills/Team | A contractor was hired to create the pH maps and then the liming prescription maps. The grower then used these maps to spread the lime with their own spreader, after an upgrade in spreader capability. The grower consulted their agronomist throughout the process as they would normally as part of their maintenance lime strategy. | A contractor was hired to create the pH maps and then the prescription liming maps. This was then used by an external contractor who applied the lime. There was limited input from the grower besides managing the process. |

| TABLE 4 ECONOMIC ANALYSIS FOR CONTRIBUTING FARMS (PARTIAL BUDGET ANALYSIS) | | | | |
|---|---|---|---|---|
| | FARM 1 | | FARM 2 | |
| Location | NE Victoria | | SW Victoria | |
| Annual rainfall (mm) | 500 | | 500 | |
| Property size (ha) | 3500 | | 2100 | |
| Area that will benefit (ha) | 500 | | 260 | |
| **GAINS** | **TOTAL** | **PER HA** | **TOTAL** | **PER HA** |
| Yield increase[1] | $3,821[2] | $7.64[2] | - | - |
| Labour cost saving | $103[2] | $0.21[2] | $2,340 | $9 |
| Variable cost saving | - | - | $10,374 | $39.90 |
| Total Gains | $3,923[2] | $7.85[2] | $12,714 | $48.90 |
| **CAPITAL** | | | | |
| Hardware purchase price | $5,000 | $10 | - | - |
| Software purchase price | - | - | - | - |
| Total Capital Investment | $5,000 | $10 | - | - |
| **OPERATING COSTS[3]** | | | | |
| Additional Variable Costs | $5,000 | $10 | $3,380 | $13 |
| Finance cost (5% of purchase price) | $250 | $0.50 | - | - |
| Depreciation (15% of purchase price) | $750 | $1.50 | - | - |
| Total Costs | $6,000 | $12 | $3,380 | $13 |
| **AVERAGE ANNUAL COSTS[4]** | $857 | $1.71 | | |
| Net Annual Benefit (discounted for 7-year life) | $3,066 | $6.13 | $9,334[5] | $35.90[5] |

*[1]Yield gains were derived from grower estimates in an average year, and declined over time as the soil acidified over the following 7 years.*
*[2]Gains have been discounted over a 7 year period to reflect the average gain for the life of the treatment in todays dollars.*
*[3] Operating costs are the total costs of the operation to begin with in the first year.*
*[4]The total costs have been averaged over a 7 year period to reflect the expected lifespan of the treatment.*
*[5]As the benefit in Farm 2 was a once off variable cost saving it was a single year benefit and no discounting was applied.*

These two examples show that there are two pathways to profit from VR lime application – saved variable costs (as per Farm 2) and increased yield (demonstrated in Farm 1).

Variable cost savings in the form of product input or labour savings relate to a single year benefit and are assessed with a simple partial budget analysis.

The yield increase scenario is more complex, as it relies on a multi-year analysis. In addition to this, it needs to be considered that the benefit of lime decreases over time as the soil continues to acidify, and that the yield benefit from the liming application will reduce over time. This has been calculated based on the need to re-apply lime in 7 years as per the grower practice.

To account for the multi-year yield gains and the future value of money, a discounting approach has been applied with Farm 1. The gains for each individual year are different as the gain is discounted each year (at 6%) to reflect the net present value of money. The average of these gains provides the average annual gain. The initial capital investment is already in current dollars and is averaged over the 7 years to provide an average annual cost. From these two figures, the 'net annual benefit' is the average of the increase in profit over the 7 years following the lime application.

Yield increase from treating acidic soil can be difficult to attribute to PA as it can also be achieved through a blanket rate application of lime. However there are areas of paddocks that require greater lime requirements than the blanket rate and will see a benefit from VR application. In some situations there are also paddocks that previously would not have been limed, but through detailed soil testing and VR liming problem areas that were previous unrecognised as acidic can be treated to increase yield. In these cases, the yield benefit is attributable to the VR application, as it would not have been achieved with a blanket approach, as was the case with Farm 1.

The additional costs involved in VR liming include extensive soil testing over and above what was previously done, and also the ownership costs associated with variable rate enabled equipment, as was the case for Farm 1. These two growers used a grid based soil testing approach. The use of a Veris machine for on-the-go sampling is also common.

Farm 1 already owned a lime spreader and the $5,000 listed as hardware purchase is the cost to have the spreader variable rate enabled. A spreading contractor was used in Farm 2, and with less lime applied in total compared to a blanket approach there was a saving in contracting costs. Keeping the capital cost of adopting VR lime as low as possible is key to maximising the economic benefits from this PA tool.

Each farm had a positive economic response from adopting a VR lime approach – with Farm 1 averaging a $6.13/ha benefit each year ($42.91 over 7 years), and Farm 2 recording a one off benefit of $35.90/ha.

The cost of the lime product used, and the amount of lime saved by using VRT (based on level of variability in paddock) will play a major role in how much financial benefit is achieved. The cost of lime on farm varies significantly across the southern region depending on access and freight, and will influence the financial benefit of adopting VR Lime. Table 5 highlights this.

**TABLE 5 THE NET BENEFIT PER HECTARE ACROSS A RANGE OF LIME PRICES AND LIME SAVINGS THROUGH THE USE OF VR LIME. THE NET BENEFIT IS AFTER $12/HA HAS BEEN TAKEN OFF FOR SOIL TESTING (ADAPTED FROM RDP 0013)**

| | | $/TONNE OF APPLIED LIME (INC. FREIGHT AND SPREADING) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **$30** | **$35** | **$40** | **$45** | **$50** | **$55** | **$60** |
| **TONNES OF LIME SAVED/HA** | **1.5** | $33 | $41 | $48 | $56 | $63 | $71 | $78 |
| | **1.25** | $26 | $32 | $38 | $44 | $51 | $57 | $63 |
| | **1** | $18 | $23 | $28 | $33 | $38 | $43 | $48 |
| | **0.75** | $11 | $4 | $18 | $22 | $26 | $29 | $33 |
| | **0.5** | $3 | $6 | $8 | $11 | $13 | $16 | $18 |
| | **0.25** | -$5 | -$3 | -$2 | -$1 | $1 | $2 | $3 |

## QUESTION 4: Are there other benefits or barriers to consider?

### Perceived operational benefits

There are clear benefits of targeting higher rates of lime to the more acidic areas in a paddock where crop growth would have previously been restricted. Benefits include increasing weed competition through healthy and more vigorous crops and increasing crop rooting depth due to subsoil pH improvement over time.

Nutrition can also be improved by raising the pH of acidic soils, as the availability of some nutrients increases.

For the growers interviewed these perceived benefits have been supported by observations of improved crop evenness through variable rate lime applications, and less variability in grain yield and quality across the different soil types in a paddock. This makes for easy management of a crop when paddocks are establishing and maturing evenly.

Generally, by applying lime using VRT, less lime product is used compared to a blanket rate approach. This results in less time spent spreading as lower rates are going out, hence a better utilisation of time and labour. The cost of the lime required each year, and freight and spreader expenses, are often less than if a blanket rate approach was used, making regular liming more affordable. In some cases this may result in a greater area of a property receiving lime, and more frequently compared to the costs of a blanket lime approach.

### Perceived whole farm benefit

The grower of Farm 1 carried out an extensive soil testing program prior to applying VR lime, which allowed for other nutrients to be tested and mapped. This included phosphorus maps, providing further agronomic and financial benefits to the enterprise.

With generally high land prices in many agricultural areas, farming businesses are finding it harder and harder to expand their land sizes. Practices such as investing in pH mapping, and VR liming is a way of increasing current land productivity, with the overarching aim to make more from the current resource.

Labour is often reduced through VR liming compared to a blanket approach, with some growers estimating a 20% reduction in spreading time.

Lentils and faba beans are pH sensitive crops that can be the 'canary in the coalmine' for acidic problems. By increasing soil pH, these sensitive pulses increase their growth and nodulation, resulting in increased nitrogen fixation to be available for the following crop. In some cases, it may preserve the use of them as a break crop, benefiting the overall rotation and farming system.

For some districts lime is a scarce resource and annual allocations are very tight. A VR approach ensures that the lime is used strategically on where it has the most benefit.

### Barriers

A common barrier is the perceived need to setup up a spreader or purchase a new one with variable rate capabilities. This equipment barrier can be overcome by using contractors for variable rate spreading. Generally VR contractors are increasing in number, however may not always be available in your area.

Whilst automated VR is easier to use in the paddock, with the large difference between rates of lime in a VR operation it can be done manually with some success. Often it is a case of a high rate of lime or none, and this can be implemented in a low-tech manner with GPS markers or a simple tablet map that highlights the position within a paddock.

Not understanding the variability of pH within and across paddocks, or lack of pH variability in the first place, is a major reason why growers may not consider this technology. In some cases, it can be difficult to see a response to lime applications, as it doesn't always fully react to show a response in year one. In addition to this, not all crop types show a clear response to lime, particularly in seasons where moisture is a limiting factor.

For some mixed farmers with small paddock sizes, a more practical approach to VR lime can be to vary lime rates between paddocks rather than within. The end result may not be as high resolution as full VR application, but the overall goal of reduced costs and more targeted liming can still be achieved.

Subsoil acidity is an issue that can slip under the detection of standard soil testing approaches. In some cases, moving from blanket rate to VR liming based off topsoil testing has resulted in issues arising with subsoil acidity, as different soil types were not receiving enough lime to account for low subsoil pH. In areas where this is a concern, EM mapping can be used with soil surface pH maps, along with ground truthing pH at depth to find subsoil pH variability.

Operationally it is important to factor in the time it takes to get paddocks tested, get results back, and then complete the liming program. If soil testing is left too late it will limit the opportunity to get the lime spread within the window before seeding, and a year can be lost.

Soil testing can be done by a grid sampling method, a Veris pH mapping machine, or in transects across a paddock. Several growers noted that you need high levels of confidence in the soil testing process, and the soil testing lab results, to proceed with VR. The greater the number of samples, the more accurate the variable rate applications will be, and ground-truthing results is always an important process in any PA technology.

A financial barrier to the adoption of VR lime is the initial soil testing costs to determine pH variability, whether through a Veris machine or through gridded soil sampling. Growers noted the initial use of cheap soil pH testing kits as a useful way to assess likely variability before proceeding to invest in more formal soil testing.

## QUESTION 5: Does the business have the capacity to usefully implement the technology?

### Implementation considerations

The path to implementation varied among the participating farms. Approaches to successful implementation included:

i) Understanding variability

- Initially checking pH variability using a cheap pH test kit to identify paddocks to pursue and investigate VR liming further.
- Grid based soil sampling to develop a pH map.
- Veris machine to get soil pH maps developed.
- Noticed areas of low pH when getting other soil tests done and decide to investigate further.
- Working on ryegrass problem areas and understanding the correlation between these and low pH.
- Investigating poor performance of lentils on certain soil types led to a need for liming.
- Discussing causes of variability with agronomist and PA provider.

ii) Creating management zones and deciding what to do differently

- Contractor to undertake the soil testing and/or pH mapping.
- Outsourcing the construction of prescription maps to PA provider or PA skilled agronomist.
- Putting test strips of lime across paddocks to observe results on different soil types before proceeding in full VR.
- Discussion with agronomist on target rates for different zones and how the response could change with different target pH levels.

iii) Machinery and technology management

- Contractors used for variable rate spreading.
- Own equipment used with an upgrade to enable automatic variable rate spreading.
- Own equipment used for manually altering rates when spreading, but not ideal setup.

iv) Data management

- Timely sampling, testing, and map preparation so it doesn't impact on other farm operations.

### Checklist

- Soil pH variability across a paddock.
- Ability to validate and map pH variability by targeted soil testing.
- Enough area under pH 5.5 (CaCl2) to make it worthwhile.
- Good source of lime.
- Access to a VR capable spreader.

## The bottom line

### Did it solve the profit constraint?

All case study participants could see that VR lime had the potential to solve the acidic soil profit constraint. For the two farms with economic information, both were increasing profit as a result of adopting VR lime (by $6.24/ha/year or a one off benefit of $35.90/ha). This was achieved either through saved lime and labour costs, or by increasing yield on low pH areas of a paddock.

### Works best when....

- There is enough areas under pH 5.5 (as per above).
- Highly variable soil type and pH within each paddock.
- Automatic VRT liming is used rather than manually.
- Quality lime is an expensive and scarce resource.
- It is tailored to individual business and recognised that different farms will have different results.
- Paddocks are larger. Smaller paddock sizes with marginal variation might be better to vary rates as a paddock by paddock approach.

### Traps to look out for:

- Subsoil acidity issues. Areas that aren't showing low pH in the topsoil, however may be acidic at depth.
- Although grid sampling and the use of Veris on the go pH sampling has increased, effective pH zones can be identified by using known soil type variation as a starting point for targeted testing, provided the sampling is rigorous through these zones.
- Not getting soil testing/ pH mapping done on time, delaying the whole process and impacting other farm operations.
- Having a fall-back plan for getting the job done if VR spreading equipment is having issues as there is a small window of time to get it done in.
- Dry seasons will limit the yield improvement from liming and slow the effect of the lime. These can lead to disappointment as the results are slower to see.


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## References


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## More Information


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