CASE STUDY

PA ASSISTED SOIL AMELIORATION

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

NOVEMBER 2019

PA for Profit: Show me the money

Introduction

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

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

This case study compares the experiences of three growers who are using precision agriculture tools to overcome various soil constraints for improved farm gross margin.

The project has identified a 5-step process (Table 1) to make sound financial decisions for 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 targeted Soil Amelioration is likely to have fit (questions 1 and 2).

TABLE 2 AREAS OF LIKELY RESPONSE FOR SOIL AMELIORATION

RAINFALL ZONE	SUBREGION	CLAYING/ DELVING	RIPPING/ SPADING	GYPSUM
LOW	Upper EP	Green	Green	Green
LOW	Western EP	Green	Green	Green
LOW	Upper North	Yellow	Yellow	Green
LOW	SAVIC N Mallee	Green	Green	Yellow
LOW	SAVIC S Mallee	Yellow	Yellow	Green
LOW	Vic C Mallee	Yellow	Yellow	Green
MEDIUM	Lower EP	Green	Green	Green
MEDIUM	Central YP	Orange	Orange	Orange
MEDIUM	Lower YP	Yellow	Orange	Orange
MEDIUM	NorthYP/Mid North	Yellow	Yellow	Green
MEDIUM	Wimmera-Bordertown	Yellow	Yellow	Green
MEDIUM	SA Upper SE	Yellow	Yellow	Green
MEDIUM	Central Vic	Orange	Green	Green
MEDIUM	Nth Central Vic	Orange	Green	Green
HIGH	SA Lower SE/KI	Yellow	Yellow	Green
HIGH	Southern Vic	Orange	Green	Green
HIGH	NE Vic Slopes	Orange	Green	Green
HIGH	Tas Grain	Orange	Green	Green

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

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 3 questions.

Details of each participant and their involvement in this survey are listed in Table 3. Several other growers were also interviewed but did not provide economic analysis. Their insights also 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 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	FARM 3
Location	Upper Yorke Peninsula, SA	Upper South East, SA	Lower Eyre Peninsula, SA
Annual rainfall (mm)	375	430	420
Property size (ha)	2350	1860	1370
Soil Types	Deep sandy rises with areas of non-wetting, and sandy loam flats.	65% grey Mallee loam, 30% sodic clay and 5% shallow sand over sodic clay.	Sandy topsoil with a sodic clay subsoil.
Crop mix	Wheat, barley, lentils.	Wheat, lentils, canola.	Wheat, barley, lentils, canola.
Participant description of farming system	Full stubble retention with no-till sowing and press wheels.	Zero-till continuous cropping with controlled traffic.	Controlled traffic, no-till, continuous cropping.
Profit opportunity	Increased yield from better crop establishment and moisture retention by reduced non-wetting nature of sand hill	Increased yield and better water use efficiency by improved soil structure on areas with gutless sand and sodic clay	Increased yield from greater utilisable area with better infiltration rates, reduced runoff and drainage to reduce waterlogging on low lying areas.
Amelioration Approach	Application of chicken litter at 3.5t/ha and incorporation and mixing with a spader	Application of gypsum to sodic areas and delving of gutless sand over clay to improve moisture and nutrient retention	Deep ripping and gypsum and lime application to improve infiltration and reduce run-off into low lying areas of the paddock, and drainage work in the low-lying parts
PA Assistance	Drone mapping of the paddock to identify variability and areas most likely respond to spading treatment. Treated 15ha of 150ha paddock.	EM38 mapping of paddocks to identify areas to delve, and variable rate gypsum application targeting sodic areas. Generally, 25% of the paddock requires treatment.	A combination of yield maps, elevation maps and EM38 & Radiometrics, to target areas for ripping and gypsum, and identify areas to avoid ripping based on boron and stone at depth.
Assumptions on benefits	1.75t/ha yield increase in wheat and barley on the 15ha treated. 0.4t/ha yield increase in lentils on the 15ha treated. The benefit from spading was assumed to be permanent and occur every year. The benefits were reported over the whole 150ha paddock as that was the area initially mapped.	Total gypsum tonnes applied has reduced by 1.4t/ha by targeting problem areas rather than blanket application. 2.5t/ha yield increase in wheat from delving. 1t/ha yield increase in canola and lentils on the areas delved. The benefit from delving was assumed to be permanent and occur every year. The benefits were reported over the whole area that was mapped rather than just the area that was delved.	On 25% of land a 1.25 t/ha yield increase in wheat and barley, and 0.6 t/ha yield increase in canola and lentils from ripping and gypsum. On 5% of area with drainage work a 1.1 t/ha yield increase in wheat and barley and 0.5t/ha yield increase in canola and lentils. It was assumed that the response from deep ripping will decline over 7 years until it will no longer provide a benefit. The response from drainage work was assumed to remain the same every year as it was a permanent fix. The benefits were reported over the whole farm as the whole farm had been mapped.

TABLE 3 BACKGROUND INFORMATION FOR CONTRIBUTING FARMS			
	FARM 1	FARM 2	FARM 3
PA Skills/Team	The grower paid a PA agronomist to make the NDVI maps by using a drone. The areas that needed to be spaded were then marked on a map on a tablet by a family member. The tablet was then given to the contractor to do the spading.	The grower made all the prescription maps whilst the delving and EM mapping was contracted out. All gypsum spreading was done by employees. The delving contractor knew where to delve as the area had been marked by the grower with an offset disc.	The grower does all the operations such as delving, lime/gypsum spreading, and drainage work themselves. EM maps were contracted out and prescription maps were made by a PA consultant. They consulted their agronomist on application rates and strategy on amelioration work.

TABLE 4 ECONOMIC ANALYSIS FOR CONTRIBUTING FARMS (PARTIAL BUDGET ANALYSIS)						
	FARM 1		FARM 2		FARM 3	
Location	Upper Yorke Peninsula, SA		Upper South East, SA		Lower Eyre Peninsula, SA	
Annual rainfall (mm)	375		430		420	
Property size (ha)	2350		1860		1370	
Area that will benefit (ha)	150		100		1370	
GAINS[3]	**TOTAL**	**PER HA**	**TOTAL**	**PER HA**	**TOTAL**	**PER HA**
Yield increase[1]	$4,055	$27.04	$11,655	$116.55	$68,030	$49.66
Labour cost saving						
Variable cost saving			$330	$3.30		
Total Gains	$4,055	$27.04	$11,985	$119.85	$68,030	$49.66
CAPITAL						
Hardware purchase price					$42,000	$30.66
Software purchase price					$1,000	$0.73
Total Capital Investment					$43,000	$31.39
OPERATING COSTS						
Additional Variable Costs[2]	$5,070	$33.80	$29,763	$282.63	$106,495	$77.73
Finance cost (5% of purchase price)					$2,150	$1.57
Depreciation (5% of purchase price)[4]					$2,150	$1.57
Total Costs	$5,070	$33.80	$29,763	$282.63	$110,795	$80.87
DISCOUNTED ANNUAL COSTS[3]	$724	$4.83	$4,252	$42.52	$15,828	$11.55
Net Annual Benefit (discounted for 7-year life)	$3,331	$22.21	$7,733	$77.33	$52,203	$38.10
Payback Period (years)	1.1		1.9		0.9	

[1]Yield gains were derived from grower estimates over time, and inherently account for a level of seasonal variability.
[2]Operating costs are the total costs of the operation to begin with in the first year.
[3]The discounted benefits and costs listed are averaged over a 7-year period that has been discounted to account for the net present value of money.
[4]Lower annual depreciation rate applied due to the nature of the hardware purchased.

Amelioration is a substantial investment but can have large payoffs. Attribution of benefits from the amelioration itself and the PA component of it is difficult. With the three examples used here, the PA approach was an enabler to undertake the amelioration, and hence it is appropriate that the whole benefits are looked at.

As amelioration benefits last more than one year, the total benefits can be very large. To account for this, a discounting approach has been applied. The benefit for each individual year is different as the benefit is discounted each year (at 6%) to reflect the net present value of money. The average of these provides the average annual benefit. 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 an average of the increase in profit over the next 7 years.

All three farms have demonstrated substantial increases in profit from their amelioration programs, ranging from $22/ha/year to $77/ha/year primarily from yield improvement, with Farm 2 saving costs on gypsum as well.

Key points:

- Amelioration would not have occurred without the use of PA technology, so the total yield benefit was attributed to the PA implementation.
- Annualised profit ranged from $22/ha to $77/ha. Farms 1 and 3 benefitted from yield improvements whilst Farm 2 benefitted from yield improvements and reducing gypsum costs.

The costs of getting maps, sensing and zone information for Farms 2 and 3 were quite high, with an initial outlay of $15/ha and $24/ha respectively. The ability to still generate a return after this investment is because there was a constraint that could be addressed. Taking a 'Profit first PA' approach ensures that data is not captured without a meaningful change in practice to follow. The long-term productivity benefits from amelioration also help to offset the initial sampling and surveying costs, rather than relying on a one-off benefit.

Amelioration projects can be complex, with more than one technique applied in a paddock. Farms 1, 2 and 3 used combinations of a range of physical amelioration (spading, delving, ripping, drainage) with the addition of manure, gypsum, and lime to achieve their yield increases. Having more than one amelioration choice within a paddock increases the value of soil sensing information, as there is greater chance to leverage from the initial investment. This is another reason why PA assisted amelioration projects can still pay their way despite the relatively large investment in sensing and mapping.

In non-wetting sand where there is a relatively simple decision such as whether to delve or clay spread, a low-tech investigation with a shovel to map out the depth to clay may be enough to guide the process. In more complex scenarios looking at multiple constraints within a paddock, a more sophisticated sensing technology such as EM and Radiometrics can be beneficial.

Various tasks for the PA assisted amelioration were contracted out. Farm 3 purchased some ripping equipment, but for Farms 1 and 2 the spading and delving were both completed by contractors. This helped to keep the capital outlay in check and meant that there was less impact on the existing labour within the business.

This analysis captures a response in time based on average yields and treatment differences observed by the participating growers. An indication of seasonal variation is given by the Seasonal Variation Index (Burke 2019). The farms in this study had relatively moderate variation with an SVI of 3 or less, whereas lower rainfall Mallee dune swale systems would experience more seasonal variation (SVI of 4 to 5).

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

Perceived operational and whole farm benefits

Not valued in the economic analysis but mentioned by all growers was the risk of incorrect amelioration. This is the risk of making an issue worse by bringing rocks or hostile subsoil to the surface during delving, or getting poor establishment and subsequent erosion after spading sandy soils. A PA assisted approach reduces this risk by showing where to stop the amelioration process.

Regardless of a high or low tech approach the most important operational benefit from taking a PA view of amelioration is developing an improved understanding of your property. The process of investigating variability, learning about its root causes, and then taking steps to address them is part of a continuous improvement process on farm. A PA approach can help with identifying patterns, locations, and areas of similar performance to assist in finetuning the investigation.

With capital intensive projects taking small steps initially as a proof of concept has merit. The use of trial strips and yield maps provides an opportunity to test amelioration on a small scale before implementing a full program across the farm. Locating the strips on representative soil types ensures that there is relevance for the results and that future investment decisions can be based on sound data. In this way a PA assisted approach can provide the confidence to commence an amelioration plan that might otherwise seem too hard, too expensive, or too risky.

Barriers

Barriers to adopting PA Assisted amelioration cited by growers and agronomists include:

- Takes multiple people and a medium-term outlook to achieve.
- The seeming complexity of amelioration can be a barrier and adding complex technology to the process can be daunting.
- Finding people to turn maps into action.
- Taking the time to do effective ground truthing.
- Co-ordinating the sensing or sampling, ground truthing, decision making on where and how to proceed, and then managing contractors and or staff to get the job done is a project in itself.
- Accessing contractors during the limited window for action.

Some amelioration approaches (spading, delving, ripping) can also leave the paddock at risk of erosion until a crop can be established. This limits how much can be practically achieved in any given year, as there are inherent risks to that years cropping program that need to be managed. Hence there needs to be a staged approach across the farm, rather than other PA approaches such as variable rate fertiliser that may be implemented all at once.

If a 'Profit First PA' approach is used, the first step is understanding that there is enough soil type and yield variability to warrant the investment and time spent on getting detailed information.

A low-tech PA approach can be appropriate for some simpler decisions. An example is the choice of delving or clay spreading when it is driven by a single factor such as depth to clay. Digging a series of pilot holes to test depth to clay and marking on a map can provide a simple, low cost way of identifying the boundary for each technique.

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

Implementation considerations

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

I. Understanding variability. Spending time digging holes or soil pits and investigating the issues, often with their agronomist.
  - Using a PA provider to clean data layers and create variability maps.
  - Involving both a PA provider and agronomist in ground truthing and interpreting variability causes.
  - Using a range of information that is available including elevation, yield, and EM maps.

II. Creating management zones and deciding what to do differently
  - Involving both the PA provider and agronomist in zone management plans.
  - Maps organised by the farmer, who has good skills in the use of the software and creating zones.
  - Outsource prescription maps construction to a PA provider or PA skilled agronomist.
  - Validate proposed approach by undertaking some trial strips in the desired soil types.
  - Allowing enough time to plan the process – decisions shouldn't be rushed.

III. Machinery and technology management
  - Conversion of existing spreader to enable VR lime and gypsum.
  - Contractors commonly used for at least part of the process.
  - Purchase of a ripper to enable more control over the process and reduce reliance on contractors.
  - Good contractors should also bring expertise to the process, by sharing knowledge from previous work in similar situations.
  - Skills within the farm business (and some help from the kids!) to manage the technology.

IV. Some other implementation tips included:

- Always ensure delving is in the direction of travel for machinery in the paddock.
- Delving is a good way to find water pipes, fibre optic cables and rocks! Locate and mark these with GPS first.
- To make it easy for delving contractor, marking out the area first with a little offset disc so that there is a visual guide to stick to.
- Analyse yield maps and look for correlations with yield maps in different seasons to identify patterns and constraints. Some constraints vary by season whereas others are there each year.
- Variable rate applications work well when the operator has some understanding of the controller in the tractor to make sure things are setup correctly.
- Have used existing EM information from years ago to correlate to depth to clay and where delving will be suited. Once you have the information it can be used for things that weren't intended at the time.
- For aggressive treatments like spading the risk of wind erosion is high if stubble cover isn't there, and subsequent depth control with normal equipment is challenging. Equipment that can seed and spade at the same time helps to combat this and get cover back as quickly as possible.

The bottom line

Did it solve the profit constraint?

The profit opportunity was optimising gross margin by increasing yield by targeting amelioration approaches to improve soil structure and water use efficiency.

In these examples a PA approach helped to unlock the benefits of amelioration and improve business profit, ranging from $22 to $77/ha/year in net annual discounted profit increase. The impact from these long term, strategic interventions was large and provided a significant boost to the businesses bottom line.

Works best when....

- There is thorough investigation of available information and time is spent ground truthing results.
- A well-planned approach is taken to implementation, that allows for some contingency of working in with contractor's timeframe.
- Some trial strips and test areas are done first to validate a response before embarking on a large program.
- There is access to resources to assist with identifying and interpreting soil sensing information.

Traps to look out for:

- Gathering too much detailed information early on without a specific purpose can lead to confusion.
- Not thoroughly ground truthing sensing information and drawing incorrect conclusions.
- Trying to do too much at once and doing a poor job of the amelioration.

Acknowledgements

The authors gratefully acknowledge the contributions of participating growers who provided their experience, insight and financial information for this work.

References

GRDC RDP00013 (2015), Output 8 – Potential trade-offs between scale and precision use of inputs, authored by Rural Directions Pty Ltd, Macquarie Franklin, Meridian Agriculture, Agripath, and Corporate Agriculture Australia

GRDC Project Code 9176123

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