CASE STUDY
VARIABLE RATE FERTILISER APPLICATION

NOVEMBER 2019

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

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 four growers who are using variable rate (VR) fertiliser (N, P, K, S) applications to optimise the farm gross margin. Several previous studies indicated a benefit ranging from -$5 to $13/ha was achieved by reducing variable costs through variable rate P, and a yield improvement benefit of $8/ha from variable rate N (McCallum 2008, Robertson et al 2007, RDP00013 2015).

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 variable rate fertiliser application is likely to have fit (Questions 1 and 2).

TABLE 2 AREAS OF LIKELY RESPONSE FOR VARIABLE RATE FERTILISER APPLICATION								
RAINFALL ZONE	SUBREGION	VR FERT	RAINFALL ZONE	SUBREGION	VR FERT	RAINFALL ZONE	SUBREGION	VR FERT
LOW	Upper EP		MEDIUM	Lower EP		HIGH	SA Lower SE/KI	
	Western EP			Central YP			Southern Vic	
	Upper North			Lower YP			NE Vic Slopes	
	SAVIC N Mallee			NorthYP/Mid North			Tas Grain	
	SAVIC S Mallee			Wimmera-Bordertown				
	Vic C Mallee			SA Upper SE				
				Central Vic				
				Nth Central Vic				

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 three 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 you 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**	**FARM 4**
Location	Upper Eyre Peninsula, SA	Lower Eyre Peninsula, SA	Wimmera, VIC	Tasmania
Annual rainfall (mm)	300	425	450	1,200
Property size (ha)	4,400	2,720	2,900	400
Main Soil Type	Sand over clay and heavy loam flats.	Sandy rises with sandy loam flats.	Self-mulching clay.	Red basalt clay loam.
Crop mix	Wheat, barley, field peas, canola & medic.	Legume (lupins, lentil, vetch), wheat, canola, wheat, barley.	Wheat, durum, canola & legume break crops.	Potatoes, wheat, pyrethrum, onions, poppies, canola.
Participant description of farming system	Continuous cropping, minimum till, full stubble retention.	No-till knife point press wheel, full stubble retention. Sustainable.	Continuous cropping, minimum till.	Diverse. Mixture of vegetable and cereal crops and some beef on the sides.
Profit opportunity	Improve yields and minimise costs on poorer performing areas.	Address variability to save on fertiliser costs and increase yield potential.	Maximising grain yield and protein; reducing inefficiencies from over-fertilising.	Improving yield and efficiency by treating areas based on soil type variability.
Previous Practice	Uniform rates of P across farm despite substantial variation in PAWC.	Uniform rates of P across farm despite 5-fold variation in PAWC.	Uniform N rate per paddock on cereals and canola.	Blanket rates of single superphosphate and sulphate of potash at sowing.
PA Approach	VR P and N at seeding. Rates 63-127% of a normal blanket rate. Liquid trace elements and P also applied at seeding at a blanket rate. Began 2008.	VR P and N replacement at seeding. Previous yield maps used to create 5 zones for prescription. Began 2008.	VR spreading of N on 2/3 of wheat and canola. Began 2014.	VR application of fertiliser to most profitable areas, as identified through soil mapping, yield mapping & NDVI maps. Began 2016.
Assumptions on benefits	No overall change in fertiliser use. Yield benefit of 0.6t/ha on flats as a result of variable rate fertiliser.	No overall change in fertiliser use. Yield benefit of 20% on the flats which make up 60% of the farm.	An increase in wheat yield of 0.25t/ha and 0.1t/ha in canola across the area that was treated with variable rate.	A $20,000 reduction in total fertiliser costs.

TABLE 3 BACKGROUND INFORMATION FOR CONTRIBUTING FARMS

	FARM 1	FARM 2	FARM 3	FARM 4
PA Skills/Team	Grower creates own prescription maps, implements with employees. External agronomist is involved in deciding what rates to apply fertiliser at each zone. Occasionally have utilised external prescription mapping services.	Grower creates and implements own prescription maps.	Grower creates own prescription maps in consultation with their agronomist. Implementation was done by the grower.	The grower hired PA consultants to create soil maps and then combined these maps with yield data to make prescription maps. Implementation was done by the grower.

TABLE 4 ECONOMIC ANALYSIS FOR CONTRIBUTING FARMS

	FARM 1		FARM 2		FARM 3		FARM 4	
Location	Upper Eyre Peninsula, SA		Lower Eyre Peninsula, SA		Wimmera, VIC		Tasmania	
Annual rainfall (mm)	300		425		450		1,200	
Property size (ha)	4,400		2,720		2,900		400	
Area that will benefit (ha)	4,400		2,720		967		165	
GAINS	TOTAL	PER HA	TOTAL	PER HA	TOTAL	PER HA	TOTAL	PER HA
Yield increase[1]	$235,908	$53.62	$252,503	$92.83	$54,302	$56.18	-	-
Variable cost saving[2]	-	-	-	-	-	-	$20,000	$121.21
Total Annual Gains	$235,908	$53.62	$252,503	$92.83	$54,302	$56.18	$20,000	$121.21
CAPITAL								
Hardware purchase price	$24,000	$5.46	$5,000	$1.84	$3,000	$3.10	$13,500	$81.82
Software purchase price	$800	$0.18	-	-	-	-	$2,500	$15.15
Total Capital Investment	$24,800	$5.64	$5,000	$1.84	$3,000	$3.10	$16,000	$96.97
OPERATING COSTS								
Additional Variable Costs	$2,700	$0.62	$2,000	$0.73	$480	$0.50	$5,225	$31.67
Finance cost (5% of purchase price)	$1,240	$0.28	$250	$0.09	$150	$0.16	$800	$4.85
Depreciation (15% of purchase price)	$3,720	$0.84	$750	S0.28	$450	$0.47	$2,400	$14.55
Total Annual Costs	$7,660	$1.74	$3,000	$1.10	$1,080	$1.12	$8,425	$51.06
NET ANNUAL BENEFIT	$228,248	$51.87	$249,503	$91.73	$53,222	$55.06	$11,575	$70.15
Payback Period[3] (Years)	0.1		0.02		0.06		1.4	
Annual Margin[4]	97%		99%		98%		58%	
Required Scale[5] (Ha)	143		32		19		70	

[1]Yield gains were derived from grower estimates in an average year.
[2]Savings in fertiliser.
[3]Capital Investment divided by Total Annual Gain minus Additional Variable Costs (excludes Finance and Depreciation costs).
[4]Net Annual Benefit divided by Total Annual Gain (includes Finance and Depreciation costs).
[5]Total Annual Cost divided by Operating Benefit per Hectare.

In each of these four examples, the practice change outlined in Table 2 provided significant financial gain for the investment in variable rate hardware.

Farms 1 to 3 achieved a yield benefit by reallocating fertiliser expenditure to yield responsive areas. Their capital outlay (<$6/ha) and annual costs (<$2/ha) was minimal and the financial benefit from refining nutrition were significant with net benefits of $51/ha to $92/ha. If new machinery was required at significant cost to implement VR, then the benefits would not have been so high.

Farms 1 and 2 were dune swale systems on the Eyre Peninsula where the previous practice of uniform P at seeding was under fertilising P responsive soils and limiting water use efficiency and yield. Variable rate application of P and N rectified this situation by increasing rates on the responsive areas.

The soil type of Farm 3 in the Wimmera varied from friable grey clays to red clay loams. The N rate was varied by soil type for both canola and some wheat, improving grain yield and protein, and avoiding haying off by over fertilisation.

Farm 4 in Tasmania made an economic gain through reducing variable costs. This was particularly important for the high production and high nutrition crops grown in that environment, where the benefits were extending beyond their grain enterprise.

This analysis captures a response in time based on average yields and treatment differences observed by the participating growers. It is important to incorporate seasonal variability when looking at returns, either by looking at a range of outcomes or using an averaging process. Gains will vary between seasons. The low cost associated with purchasing and operating the technology means that there is little to lose by applying zone management, if the variation in soil type exists.

In each of these examples the capital outlay to convert to VR use was minimal which made the overall benefit higher. The initial capital cost used in the economic analysis is a mixture of the cost to convert machinery to variable rate capability, and the extra cost associated with purchasing new equipment with variable rate capability.

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

Perceived operational benefits

The growers observed several other operational benefits that weren't included in the economic analysis. These include:

- More even crop establishment and maturity across the paddock, assisting weed control timing and harvest management where P rates were varied between management zones.
- Matching N rate to yield potential based on soil type reduced the incidence of haying off.
- Improving crop nutrition on the responsive soil types also improved crop competition with grass weeds, particularly when upfront N and P at seeding are applied to responsive soil types.
- Automated Variable Rate reduced the risk of operator error and fatigue compared to manually adjusting fertiliser rates on the go where land changes were distinct enough to do so.

Perceived whole farm benefit

The tactical strategy of VR fertiliser application based on management zones derived from data layers such as yield maps, NDVI imagery, elevation, and EM surveys, is often the entry point to understanding variability in soil type, PAWC and soil constraints across the farm. Once the level of variability was recognised, higher cost strategic profit opportunities were pursued utilising PA to manage the costs involved. Examples include addressing acid soil areas with VR liming and improving PAWC though amelioration strategies such as delving, deep ripping or spading.

Barriers

Barriers to adopting PA assisted VR fertiliser application cited by growers and agronomists include:

- Not knowing the true level of soil type and PAWC variability across the farm and the financial implications of that variability.
- Assuming it is a complicated and costly exercise to create management zones from data layers and to then implement VR technology in the paddock.
- Not knowing how, where, or who to contact to access the required information.

The challenges cited by those using VR fertiliser to manage soil type variability include:

- The initial investment in time and money required to create data layers, conduct soil tests, and set up machinery, ensure compatibility between equipment, software and hardware.
- Time spent loading files into the tractor for seeding and spreading.
- Training machinery operators to use the technology and avoid operational errors.
- Ensuring the time required to manage the technology does not impact on timeliness of other operations.

If a 'Profit First PA' approach is used, the first step is understanding whether there is sufficient soil type and yield variability to warrant the investment and time into adopting VR technology.

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

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

i) Understanding variability

- Using a PA provider to clean data layers and create variability maps.
- Involving both growers, PA providers and agronomists to ground truth and interpret variability causes.
- Understanding PAWC by soil moisture monitoring

ii) Creating management zones and deciding what to do differently

- Involving both PA providers and agronomists in zone management plans.
- Outsource prescription maps construction to a PA provider or PA skilled agronomist.
- Validate fertiliser strategies with test strips, supported by soil and plant analysis and soil moisture monitoring.

iii) Machinery and technology management

- Variable rate technology was acquired when upgrading seeder.
- Investing in software and hardware upgrades to ensure compatibility.
- Enough support from machinery dealers, software and hardware providers and PA support advisers.
- Skills and interest within the farm business to manage the technology.

iv) Data management

- Efficient file management to enable timely use of maps.

The bottom line

Did it solve the profit constraint?

The profit opportunity for VR fertiliser was optimising gross margin by matching fertiliser requirements to soil type and yield potential. This was achieved in all four cases with net annual benefit between $18 and $92/ha/year.

In some seasons, the economic benefit came from increasing nutrition in the high yield potential zones, while in other seasons, economic benefit was gained from better grain quality achieve by reducing N rates on lower yield potential areas and avoiding haying off.

Profit gain occurred by applying fertiliser to where the response was greatest or to the level required to meet yield potential. The benefits were highly situational and varied between farms and seasons.

Works best when....

- Variability is enough to justify VR implementation.
- There is access to resources (skills, equipment, advice) needed to carry out each implementation step.
- Capital investment in equipment doesn't erode the potential economic benefits.
- There is access to timely technical support when things go wrong during paddock operations.
- As applied maps are captured and compared to original prescriptions to ensure that false conclusions and results aren't obtained.
- Seasonal variability is well accounted for when assessing economic responses.

Traps to look out for:

- Investing in the technology before knowing the extent of the variability.
- High cost data capture that outweighs the potential returns.
- VR implementation process impacts on timeliness of farm operations.

Acknowledgements

References

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GRDC Project Code 9176123

More Information

Patrick Redden & Royce Pitchford
Rural Directions Pty Ltd
(08) 8841 4500

Kate Burke
ThinkAgri Pty Ltd
0418 188 565