Potential cost savings from variable rate technology in site specific crop management in the Victorian Mallee

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Abstract

Variable rate technology (VRT) can be profitably used to increase the efficiency of site specific crop management (SSCM). Yield benefits from using VRT to conduct SSCM at a finer scale than already practiced may be theoretical, because of the large scale of spatial variation, the uncertain season, and the interaction between season and management in the Mallee environment. However, cost savings from increased operational efficiency are more likely and reliable and may justify introducing VRT in its own right. This paper calculated cost savings in two case study paddocks (high and low variable cost) to investigate the likely profit benefits of using VRT to apply variable nitrogen management compared with current SSCM techniques.

There were timeliness benefits from working the paddock as one, up and back and on more complex paddocks. Cost savings from working the low variable cost paddock as one (round and round) would alone be sufficient ($1.23/ha) to justify investment in simple GPS-driven switching technology for pre-drilled urea, but not an upgrade to a VRT triple-bin seeder ($1.52/ha). Contract broadcasting before sowing was a profitable and convenient VRT technology for the high-cost paddock ($8.96/ha profit). The total cost saving from a VRT triple-bin seeder depended on assumptions about nitrogen loss ($0.21/ha/10% loss to $3.54/ha/10% loss) and significant intangible costs related to farm infrastructure and the timing of the management decision. VRT offers additional benefits such as to eliminate the need to work paddocks in patches, reduce worked area, and may reduce nitrogen losses from leaching or volatilisation. VRT should also insure against errors made in manual application. Small savings in area (1.0-0.6 %) were made by working the paddocks as one and in a round and round direction.

Keywords

Precision farming, Economics

Introduction

There may be opportunities for variable rate technology (VRT), as a component of precision farming strategies, to reduce the cost of site specific crop management (SSCM) in the southern Australian Mallee. Previous work (1) has shown that profitable SSCM depends on (i) significant spatial variation across a paddock that directly impacts upon production, (ii) reliable mapping of the variation, (iii) a known production function and (iv) lack of alternative methods of managing the variation. The dune/swale features and subsoil limitations to production in the Mallee satisfy the first two criteria. Crop response to management on dune/swale features and subsoil limitations are known only if the season can be reliably predicted, so criteria (iii) is not satisfied without reliable weather forecasts.

Many Mallee farmers already practise SSCM to some extent by sowing malt barley or pre-drilling or broadcast before seeding nitrogen as urea on light textured soil. Variable rate fertiliser application is a potentially more efficient method for applying nitrogen. The aims of this paper were to calculate the potential for cost savings from using VRT, and thus the likely profitability of investing in the technology, relative to other methods for achieving SSCM in the Victorian Mallee.

Methods

The benefits of VRT relative to current SSCM techniques were the area saved in headlands relative to working the paddock as one, related savings in machinery and input costs, and savings in extra operations (eg. broadcasting urea) that were no longer required. Area calculations were made on two case study paddocks with distinct spatial variation, selected from Birchip Cropping Group focus paddocks. Anderson's (100 ha) contains a central dune (21 ha) that was sown to malt barley in 2001. Funcke's (180 ha) contains a central saline patch (30 ha severely affected, 10 ha moderately affected) that was sown to canola in 2001 and not given a separate management treatment. There was a significant impact on yield (0.9 t/ha to 1.5 t/ha) and the farmer will not apply urea on the saline patch in future.

Area calculation – round and round

The area worked in 'round and round' RNR was calculated using the following algorithm: Lines were made bisecting each corner of the paddock. Two corners become one where these lines meet. The shortest tangent line from the adjacent side of the paddock determines the number of laps made before two corners are 'filled in'. The area was calculated for each side and headland (a fixed number of machinery widths) at this distance. The area in corners was calculated and the side lengths reduced to account for turns. The algorithm was repeated with the new corners until the final shape was a triangle. A final headland was made to 'finish' the paddock.

Up and back

The area worked in "up and back" UNB was calculated by reducing the actual paddock area by the 'real headlands'- the turning radius plus the turning radius times sine of the angle of the headland to the direction of travel. The reduced paddock area was adjusted for overlap, and the number of machinery widths required to cover the turns on headlands multiplied by the headland length to get headland area. The distance travelled during the 180? turns in the headlands of UNB was approximated by a semi-circular path.

Machinery and economic analysis

Anderson's sow with an 8 m air seeder and Funcke's a contract 12 m air seeder. Both were interested in updating technology to improve the efficiency and reliability of their SSCM. Turning radius at the implement centre was assumed to be equal to implement width, and overlap 0.3 m. Variable costs for cropping and machinery costs for Anderson's (owned) were taken from Hall (2). Commercial contract rates were used for Funcke's and economic calculations only made on UNB basis because they do not use RNR. Urea rates were 25 kg/ha at Anderson's and 100 kg/ha at Funcke's, costed at $425/ton.

Results and Discussion

Analysis of area – working method

RNR worked the most area (Table 1), wasting 4.4 % of inputs above UNB. In UNB there was also about 3.5 % of area in 'unworked turns' (where the machine was taken out of the ground on the headland). If the turns were made at the same speed or less than normal working, RNR would be slightly more (Funcke's) or equally (Anderson's) time-efficient; the total driven area in UNB (worked area + unworked turns) was slightly higher. Unworked turns at Funcke's have no direct impact on costs because they are factored into the contract cost and the contractor is only paid on worked (ground engaged) area.

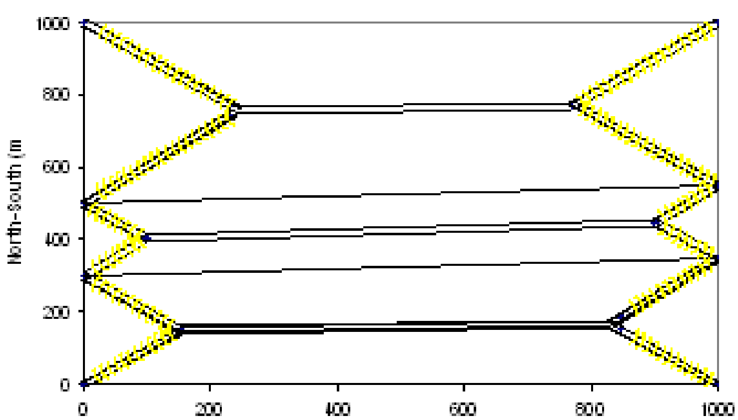
Working in patches

There was little increase in area when simple (Anderson's) and more complex (Funcke's) paddocks were split into patches (1.0-0.6 % in RNR, Table 1). This was because the area of headland in the corners remained about the same when the paddock was split up (Figure 1). The additional area came from the central headland in each patch. These become longer as the patches become less square. When the paddock was split into patches under UNB, there was no change to the worked area (the calculations assume the implement is removed from the ground at exactly the edge of the patch). However, the area of unworked turns increased in the more complex paddock (Funcke's, 38 %).

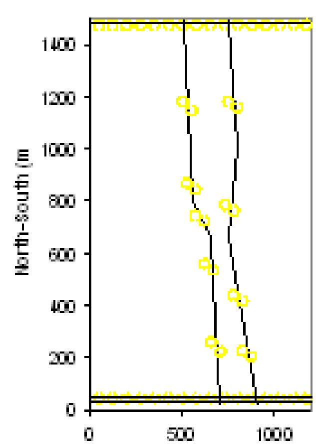
The worked area was sensitive to overlap, but relatively insensitive to machinery width. Worked area increased 1 % for each 1 % increase in overlap in UNB, and 1.1% in RNR. The additional 0.1% in RNR came from effect of overlap on the number of turns.

Table 1. True paddock area and area worked calculated for paddocks at Anderson's and Funcke's worked as a whole and in patches, and RNR or UNB. [1]UNB = east-west for Anderson's, north-south for Funcke's. [2]Figures in brackets are the area in unworked turns in hectares.

		Area (ha)				
Farmer		Anderson			Funcke	
Working Method[1]		RNR	UNB[2]		RNR	UNB[2]
True Area		100.0			180.0	
Worked as One		109.6	105.2 (3.8)		193.1	187.2 (6.8)
Patch 1	S flat	36.7	34.2 (1.3)	W rise	101.2	93.2 (4.0)
Patch 2	Hill	21.9	21.0 (1.0)	Flat	30.8	31.3 (2.5)
Patch 3	N flat	52.1	50.0 (1.9)	E rise	62.7	62.9 (2.8)
Total Patches		110.7	105.2 (4.2)		194.7	187.2 (9.3)



a. Anderson's



b. Funcke's

Figure 1. Diagrams of headlands and turns for Anderson's worked round and round in patches (a), and Funcke's worked up and back in patches (b). Double lines indicate passes covering headlands, circles turns on headlands.

Economic potential for new SSCM technologies

We hypothesised that VRT with a triple-bin seeder would be a more efficient way of applying nitrogen because the paddock would not have to be worked in patches, or nitrogen applied with a separate application. The area analysis showed that the potential savings in worked area were minimal (for RNR, 1.1 ha at Anderson's, 1.6 ha at Funcke's, for UNB 0.4 ha at Anderson's and 2.5 ha at Funcke's in unworked turns that do not have a direct consequence for the farmer). The main opportunity for saving was changing from RNR to UNB or reducing overlap, saving $112 for each worked hectare at Anderson's and $254 at Funcke's.

Partial budgets were calculated for several possible SSCM practices, relative to either sowing barley on the hill with all work done in patches (Anderson's), sowing wheat on the hill and being limited to work in patches because of pre-drilling urea (Anderson's), or broadcasting urea across the whole paddock (Funcke's). The largest benefits obtained at Anderson's (up to $1.52/ha, Table 2) came from working the paddock as one in RNR. The savings from working the paddock as one and switching pre-drill urea on/off from the cab or with GPS were nearly as great ($1.23/ha). The benefits were less in UNB, because the only advantage to working the area as one was in reducing the area of unworked turns. The scale of benefit at average farm sizes worked RNR (eg. 1000 ha cropped, $1230-$1520/ha) would be sufficient to justify small investments (eg. GPS-driven switching of air-seeder clutches) but much larger cropped areas would be required to justify the additional cost of a VRT triple-bin air cart.

Not broadcasting urea on the saline patch at Funcke's saved $8.96/paddock ha (Table 2). The additional benefit from applying the urea at sowing came only from not paying for the contract broadcaster ($5.72/ha on the whole paddock). This was the marginal price that could be paid for a contract triple-bin seeder with VRT and would decrease to $3.30/ha if half the paddock was saline.

Table 2. Economic benefits of SSCM practices relative to working in patches and sowing barley on the hill, or pre-drilling urea in patches. [1]Relative to working patches separately throughout the season, sowing barley on hill. [2]Relative to pre-drilling urea on hills as a separate patch. [3]Sowing Canola in the case of Funcke's, relative to broadcasting urea across entire paddock.

	Saving/hectare		
Farmer:	Anderson's – RNR	Anderson's – UNB	Funcke's – UNB
Practice:			
Work patches together until sowing, leave smooth[1]	$0.32	$0.02	
Pre-drill urea on hill(s) using switching/VRT[2]	$1.23	$0.05	
Broadcast urea on hill(s), incorporate by sowing[2,3]	$0.43	$0.05	$8.96

Apply urea on hill(s) at sowing using switching/VRT[2,3]	$1.52	$0.05	$14.68

The benefits from VRT insuring against application errors and minimising nitrogen loss depend greatly on assumptions but can be quantified. Each additional hectare of urea applied in error cost $0.11/paddock ha at Anderson's, and $0.24/paddock ha at Funcke's. Every 10% loss of urea by leaching or volatilisation would add $0.21/ paddock ha at Anderson's, and $3.54/paddock ha at Funcke's. These figures would be magnified by any yield response (positive or negative). The cost effects that were hardest to quantify and probably most important to consider, relate to the additional on-farm infrastructure required to handle a third product at sowing time, being able to shift this responsibility to a third party in the case of broadcasting, and the risk of making the investment in urea in advance of sowing.

Conclusion

The benefits from using VRT to reduce the cost of SSCM in two case studies in the Mallee depended on overall input costs and the proportion of paddock area treated. Even with low input costs on a relatively small farm, the cost savings ($1.23/ha) would justify simple GPS-driven switching of pre-drilled urea. Contract GPS-driven broadcasting of urea was profitable ($8.96/ha) compared with a blanket broadcast at high (100 kg/ha) urea rates. High input costs, large sown areas, and high urea loss through leaching or volatilisation would contribute to the profitability of investment in a VRT triple-bin air cart.

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