Matching inputs to soil potential in low-rainfall cereal systems of the Upper Eyre Peninsula

Cathy Paterson[1], Roy Latta[1], Nigel Wilhelm[1] and Anthony Whitbread[2]

[1] SARDI, Minnipa Agricultural Centre, PO Box 31 Minnipa SA 5654. Email: cathy.paterson@sa.gov.au
[2] CSIRO Sustainable Ecosystems, PMB 2 Glen Osmond 5064.

Abstract

Low-rainfall farming systems must be low-risk, flexible and responsive. Inputs need to balance the best agronomic and economic advice with the need to ensure reliable outcomes at low cost. Variable-rate technology (VRT) offers farmers the ability to adjust seed and fertiliser rates during the seeding process, to change inputs according to the production capability of different paddock zones or soil types. Using a combination of historic grain yield, EM38, elevation maps and soil chemical analysis, a paddock at the Minnipa Agricultural Centre (MAC) was segregated into 3 zones. In 2008 and 2009, the inputs of seed and fertiliser were applied at low, standard (district practice) and high rates sown in alternate strips using a whole-of-paddock design. Therefore, the effects of the 3 input levels on crop performance could be evaluated over the 3 zones in an extremely dry year (2008, decile 1- 139 mm GSR) and in a wet year (2009 decile 9- 333 mm GSR). A gross income analysis of 3 blanket-input systems and 2 variable-rate approaches has shown that a low-input blanket application of seed and fertiliser and a low-risk, variable-rate approach would have resulted in increased income above a standard-input, blanket-application of seed and fertiliser. In 2010, a decile 8 year (273 mm April to September) there has been a reduction in early dry-matter production in the low-input treatment across all zones.

Key Words

Yield potential, Variable-rate technology, responsive farming, risk management.

Introduction

To manage business risk, it is important for low-rainfall farming systems on the upper Eyre Peninsula to be flexible and responsive to soil and season. Due to the region's highly variable seasons and soils, paddock inputs need to balance the best agronomic and economic advice with the need to ensure reliable outcomes at low cost. Variable Rate Technology (VRT) offers farmers the ability to adjust seed and fertiliser rates during the seeding process (Adams et al. 2000), according to the production capability of different paddock zones or soil types. Previous research investigating increased seeding rates and fertiliser applications found that in a good season, reduced canopy size reduced yield on all soil types (Hancock 2006), while in a poor season grain yield increased with smaller canopies on heavy/shallow soil types (Hancock 2007), indicating that by adjusting inputs across paddock zones, farmers can better target potential yield and paddock profitability. However, researchers on the upper Eyre have also reported no better economic returns from the use of VRT technology compared with the standard practice of applying fertiliser and seed at blanket rates (Hancock 2008). At Minnipa Agricultural Centre (MAC) the production and economic consequences of variable-rate technology are being evaluated across a range of seasons in low-rainfall, upper Eyre Peninsula farming systems. The trial reported in this paper was established in 2008 and is continuing for a further 3 seasons.

Methods

A 61 hectare paddock (N1), at MAC, was segregated into 3 zones in 2008 by combining knowledge about historic grain yield, EM38 and elevation maps to produce 3 distinct production zones defined as good, medium and poor. Prior to the start of this study, the paddock was managed in a typical cereal-pasture rotation with uniform seed and fertiliser inputs. Prior to seeding in 2008, 4 sampling locations per zone were geo-referenced and soil and crop monitoring took place at these positions in all years. Chemical analysis on soil samples collected prior to seeding in 2008 and 2009 included plant available P (Colwell) and total mineral nitrogen (Table 1). In addition, the 2008 soil samples were analysed for phosphorus buffer index (PBI) to indicate sorption capacity and its effect on the availability of soil P (Moody 2007), and the concentrations of boron, chloride and calcium carbonate to define subsoil constraints. In 2008 and 2009, 3 rates of seed and fertiliser were sown in alternating strips across the paddock (Table 2), in the same positions each season, using Wyalkatchem wheat sown on 21 May in 2008 and 5 May in 2009. In 2009, foliar N was applied on 27 July (Zadoks growth stage 37) at 10 and 20 kg/ha N to the standard and high-input treatments, respectively, in response to Yield Prophet predictions of an economic N response. The entire paddock was maintained weed free with the same management across all zones.

Table 1: Soil characterisation for zones in paddock N1, MAC 2008 and 2009

	Good		Medium		Poor	
	2008	2009	2008	2009	2008	2009
Colwell P 0-10 cm (mg/kg)	28.0	32.5	36.0	39.5	39.0	39.3
Total Mineral N 0-0.6 m (kg/ha)	226	142	275	158	242	231
PBI 0-10 cm	77.9		96.1		98.6	
Depth to soil $CaCO_3$ > 25% (m)	0.6		0.4		0.2	
Depth to B > 15 mg/kg (m)	1.0		0.6		0.8	
Depth to Cl > 1000 mg/kg (m)	0.8		0.6		0.4	

Table 2: Sowing inputs for treatments in paddock N1, at MAC 2008 and 2009

Treatment	Seed Rate (kg/ha)		DAP (kg/ha)		Foliar N (kg/ha)	
	2008	2009	2008	2009	2008	2009
High	50	55	60	60	Nil	20
Standard	50	55	30	30	Nil	10
Low	35	40	Nil	Nil	Nil	Nil

A plot harvester was used to reap two 20 x 1.5 m strips in each sowing treatment around the geo-referenced sample points, to calculate grain yield. Grain samples were taken and analysed for quality in both years. Gross income analyses of treatments within each zone were used to compare different system approaches; this was done by calculating the income from grain yield and subtracting the treatment input costs (Table 3).

Table 3: Input costs and income ($/t) at Minnipa for 2008 and 2009

Year	Seed Cost ($/t)	DAP ($/t)	Foliar N ($/L)	Grain Income APW 1 ($/t)	Grain Income AGP 1 ($/t)
2008	350	800	nil	261	241
2009	350	870	0.74	224	n/a

Treatments applied to VRT combinations used for gross income analysis are outlined in Table 4. These two VRT combinations were then compared to the gross income as if the three different input treatments had been applied to the whole paddock, taking into consideration the zone area percentage outlined in Table 5. The VRT - 'Go for gold!' approach intended to increase profitability by reducing inputs on areas with poor yield potential but increasing inputs on high potential areas. The VRT – 'Hold the gold!' was an approach aimed at reducing risk by keeping inputs for the good zones as standard and reducing inputs on both the medium and poor zones to low.

Table 4: Treatments applied to VRT gross income analysis for N1, MAC 2008 and 2009

Paddock zone	VRT – Go for gold!	VRT – Hold the gold!
Good	High	Standard
Medium	Standard	Low
Poor	Low	Low

Results

Minnipa is in a Mediterranean-type climatic region with an average annual rainfall of 325 mm and average growing season rainfall of 242 mm. Monthly rainfalls for 2008 (decile 1, 139 mm GSR) and 2009 (decile 9, 333 mm GSR) are summarised in Figure 1.

Soil in the poor zone of N1 was characterised by high reserves of N (0-0.6 m) and P in the surface layer compared to the medium and good zones, but with hostile levels of boron and salt restricting the potential rooting zone. By reducing plant available water capacity (PAWC), subsoil constraints will usually reduce the productivity of cereals as the crops are more reliant on rainfall than stored soil moisture. In 2008 and 2009,

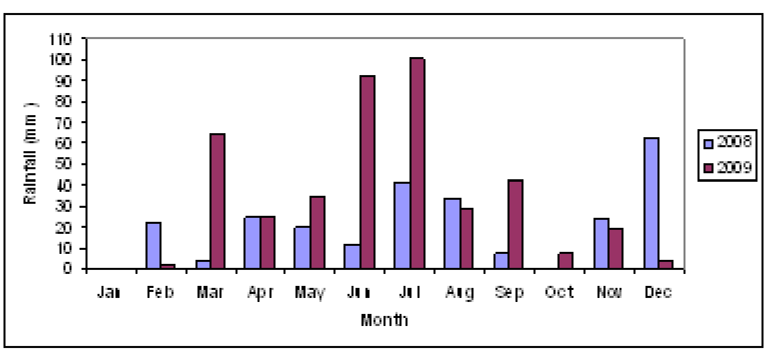

Figure 1: Monthly rainfall for Minnipa, 2008-09

the concentration of Colwell P, when corrected with the PBI as proposed by Moody (2007), suggest that a

yield response to P was unlikely. The reduction in mineral N in 2009, especially in the good and medium zones, may be attributed to the rainfall received in December 2008 and March 2009. The high amounts received in these months probably led to the leaching of N through the soil profile.

In 2008 grain yields were highest for the good zone, while the medium and poor zone achieved similar but lower yields (Table 5). There was no yield response to phosphorus or nitrogen in the dry year, as grain yield did not change when fertiliser was halved or reduced to nil.

Grain quality was generally good for all treatments with high protein, screenings under 5% and adequate test weight (>74 kg/hL, data not presented) and achieved Australian Premium White 1 (APW 1). The exception was the medium soil, low- and high-input treatments which had higher screenings segregating the grain to Australian General Purpose 1 (AGP 1). The higher screenings in this zone may be attributed to the boron layer becoming toxic at 0.6 m, causing the plants to come under moisture stress earlier than the other zones in a dry year. Reflecting grain yield, gross income was highest for all good zone treatments. The low input treatment gave the highest gross income across all zones as there were no fertiliser costs and no loss in grain yield.

Table 5: Sowing inputs, grain yield and quality and gross income for treatments in paddock N1, at MAC, 2008 and 2009

Paddock Zone	Paddock Area (%)	Treatment	Grain Yield (t/ha)		Protein (%)		Screenings (%)		Gross Income ($/ha)	
			2008	2009	2008	2009	2008	2009	2008	2009
Good	55	High	0.74	3.0	14.7	11.5	2.9	0.4	103	589
		Standard	0.68	3.0	14.7	11.4	2.8	0.3	132	621
		Low	0.72	2.9	14.2	10.9	3.3	0.4	142	636
Medium	20	High	0.59	3.3	15.7	11.8	5.5	0.4	31	656
		Standard	0.56	3.2	15.1	11.5	3.6	0.5	64	666
		Low	0.57	3.3	15.5	11.2	6.3	0.4	79	725
Poor	25	High	0.42	2.6	15.0	13.0	3.1	0.4	37	499
		Standard	0.41	2.5	14.6	12.5	2.9	0.5	68	509
		Low	0.44	2.5	14.6	12.3	3.8	0.4	82	547

LSD (P= 0.05)	*n.s.*	*n.s.*	*0.5*	*1.0*	*0.12*	*0.3*

In 2009, the 3 variable crop inputs produced similar grain yields within the zones; the poor zone grain had higher protein content than the medium and good zones. Grain quality was excellent with screenings <1% and test weight >81 g/hL irrespective of treatment or zone (data not presented) and all zones achieved APW1. Reflecting grain yield, the medium zone generated the most income per hectare, while the poor zone generated the least in 2009. For all zones, the low-input strategy generated the highest gross income, due to no fertiliser costs and no loss of grain yield or quality.

When fertiliser inputs were reduced to zero gross income was maximised and the low input system across both seasons on all zones was most profitable (Table 6). In 2008 and 2009 the Hold the Gold! VRT approach was more profitable than the standard and high input blanket approach (as if the whole paddock had been managed as one zone).

Table 6: Comparison of the gross income of different sowing regimes compared to VRT rates across the whole 61 ha paddock

Treatment	Gross Income 2008 ($/ha)	Gross Income 2009 ($/ha)	Accumulated Gross Income ($/ha)	Accumulated Gross Income cf. standard input treatment ($/61ha)
VRT – Go for gold!	90	600	690	-366
VRT – Hold the gold!	109	616	725	1,769
High input blanket treatment	72	566	638	-3,538
Standard input blanket treatment	102	594	696	0
Low input blanket treatment	114	631	745	2,989

Conclusion

The low-input treatment generated the highest income at Minnipa in both a decile 1 and a decile 9 year. Not applying any fertiliser has not resulted in any yield penalties to date, due to the high background soil concentration of N and P. This can be partly attributed to the run of poor seasons prior to 2009 and a history of fertiliser inputs exceeding plant requirements. These production outcomes match the predictions from the soil analyses with sufficient P and N to grow >3 t/ha wheat crop.

A conservative VRT approach (Hold the gold!) was more profitable than a standard-input, blanket-approach to sowing a wheat crop at Minnipa in both seasons. This approach currently offers farmers the opportunity to operate at a lower risk level by reducing inputs on poorer-performing areas of paddocks, where nutrition is generally higher because of years of fertiliser application exceeding plant requirements, but still apply inputs on the better areas of paddocks to maximise crop production in the good zones. The higher-risk VRT approach (Go for gold!) was less profitable than the standard-input, blanket approach.

Research will continue to monitor the interplay of seasons, soil fertility and variable inputs. It is intended to apply the three treatments to the paddock for the next 2-3 years to track the long-term impact of changing inputs, how the different zones respond to different treatments in different seasons. In 2010, the low input treatment is showing a decline in dry matter production given a decile 9 in 2009 followed by a decile 8 season in 2010. The research will continue for another 2 seasons to determine if there is a long-term economic advantage to using VRT in a low-rainfall farming system.

Acknowledgements

Thank you to GRDC for providing the funding for this research.

References

Adams ML, Cook S, and Corner R (2000). Managing Uncertainty in Site-Specific Management: What is the Best Model. Precision Agriculture, 2, 39-54.

Hancock J (2006). Canopy management on upper EP. In Cook A. et al. (Eds) Eyre Peninsula Farming Systems 2005 Summary. PIRSA Publishing Services, South Australia. ISBN 0-7590-1376-4. pp 25-26.

Hancock J (2007). Canopy Management on Upper Eyre Peninsula. In Cook A. et al. (Eds) Eyre Peninsula Farming Systems 2006 Summary. PIRSA Publishing Services, South Australia. ISBN 978-0-7590-1394-0. pp 91-92.

Hancock J (2008). Variable Rate Technology at Minnipa and Mudamuckla- is it Worthwhile? In Scholz N. et al. (Eds) Eyre Peninsula Farming Systems 2007 Summary. PIRSA Publishing Services, South Australia. ISBN 978-0-7590-1394-0. pp 106-108.

Moody, PW, (2007). Interpretation of a single-point P buffering index for adjusting critical levels of the Colwell soil P test. Australian Journal of Soil Research 45, 55-62.