Poorer performing paddock areas; do we:-
Invest in amelioration, Vary input rates or Cull areas from the cropping system (IVC)

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Abstract

Poorer performing paddocks have plagued farmers often because paddocks tend to be treated as homogeneous when most are heterogeneous in the response to our current systems. The treatment of these paddocks requires that knowledge of where yield and quality differences are occurring. Differences in yield and quality necessitate a response action to occur to ensure that the management of these paddocks change. The purpose of zone management is to optimise the yield and quality of produce from the inputs applied to achieve high output/input ratios across the zones within the paddocks.

The identification of performance differences in paddocks ensures that more efficient zone management practices can be applied to the paddock increasing the chances to profit. The benefits to the grower are that they are able to focus at a paddock level, assess change and viability of change to their practices.

Introduction

Since mankind has heralded the arrival of mechanisation, the ability to be able to crop large paddock units has increased as has the speed at which the agricultural operations can occur. This has occurred across a wide cross section of agricultural commodities. A paper presented in the Australian Sugar Industry in 2000 stated before mechanisation, row interspace distances were varied to suit the growth habit of particular varieties and access for man and the horse. (Robotham B 2000). The use of mechanisation has lead to a myriad of problems and opportunities across all agricultural sectors.

The problem that this paper aims to address is the decision making for poorer performing broad acre areas. These are predominantly cereal cropping paddocks within the agricultural zone of Western Australia.

A survey of 28 grower groups confirmed that paddock variability was a key indicator of biophysical factors limiting crop paddock performance. In 86% of responses, paddock variability was seen as a significant feature of poorer performing paddocks. (Blake J 2001)

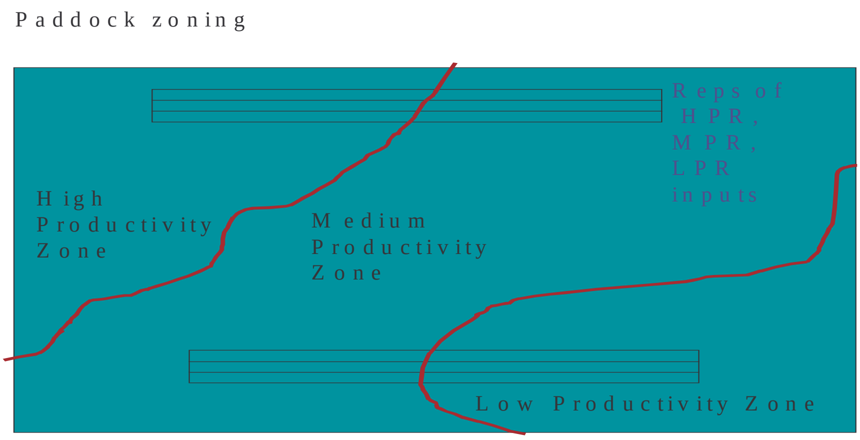
Zone Management

Zone management is the treatment of a specific area to improve productivity. Alex McBratney in 2001 defined zone management as recognising areas within paddocks, which have similar yield potentials and can be managed relatively uniformly.

These zones cane be identified from aerial photos, remote sensing imagery (multispectral), NDVI imagery which is approximately equal to biomass. A series of satellite images are translated into yield maps showing consistent yield variation over a number of seasons. Farmers are adept at visual identification through their constant monitoring of crops.

Figure 1 describes visually how a paddock performs due to physical differences. Trial data from within the paddock details how the zones performed with various treatments.

Fig 1. Diagram of paddock zones derived from satellite imagery.



*HPR, MPR, LPR refers to high, medium or low level of inputs (usually fertiliser and seed inputs etc).

With increasing technology such as yield mapping we are better able to analyse paddocks and record data. This data with improved mechanisation allows us to be able to tailor input packages to suit paddocks and parts of paddocks. With these advancements the time of treating paddocks as homogenous products is all but over. Smart farming recognises the differences within paddocks and seeks to treat them accordingly. The focus of the problem is narrowed down to zone management and the input rates that can be applied to achieve a greater economic return. The application rates of inputs to land should be adjusted as conditions within or across a paddock vary.

A major advantage of precision agriculture is that it provides farmers with an analytical capability to assess the likelihood of benefit and hence improve decision making (Cook et al 1996).

The analysis of yield mapping allows for the economic calculation of inputs that ensures that the risk of farming is further minimised as far as practicable. This is further aided with long term trial data across a range of seasons and crop rotations. An agronomic / economic calculator was developed by the Department of Agriculture Western Australia and Planfarm Pty Ltd to calculate inputs and effects upon economic returns. The need to pull data together from trials is seen as a logical step forward to ensure more effective farming is performed. Tanewski G in 2000 succinctly stated this as; given that agriculture is especially vulnerable to production risk, the relevance and type of business planning conducted by farmers will depend on the extent to which they believe they can influence the performance of their farm business through their own actions.

Zone management, by its very nature, is a value-based project that strives to improve management and sustainability. It is allowing the farm managers to be able to make the decisions necessary to ensure the resource (land) remains productive currently and into the future. This ensures that the land is sustainable and that the business is profitable. “The value based approach assumes that the productive capacity of the business is being maintained. For a farming business this must include…maintenance (or replenishing) of soil fertility.”

(Shadbolt and Morriss 1999) Zone management is adding value to farming enterprises through its ability to provide a decision support tool that farm managers can use to improve their productivity and quality, their resource base and their capital base. The resource base is what drives a farms potential direction and generates the capital to keep farm enterprises driving in a particular direction. If we are able to improve soil productivity we must also be able to increase yield and quality and potentially profits.

Method

Data has been collected over the last 17 years from onfarm trials and from a range of projects that demonstrate that with various treatments at different rates different outcomes were achieved. Data has been included from systems projects like "economic comparison of farming systems for the medium rainfall northern sand plain" (Peek 2002) and "impact of claying on grass weed management and profitability" (Blake 2002). Such trails provide data, which was used as the base data from which to develop an agronomic and economic model.

Aerial photos were also collated as a visual aid to identify areas that had over a range of seasons yielded at different rates. The series of aerial photos over time provides a cross section of crops and seasons. It could be clearly seen with this visual identification, paddocks that needed to be investigated due to differentially performing areas. Aerial photos are a tool that can be used by farmers.

Through analysis of zone management an "invest in amelioration, vary the input rates or cull" program was developed. The IVC program is a farmer friendly automated decision model. An agronomic page has combined multiple treatment options together. Data relating to:

1. Ameliorative treatments – example lime;
2. Seasonal inputs of a macro nature – example nitrogen fertilizer;
3. Seasonal inputs of a micro nature – example manganese fertilizer;
4. A combination of treatments; and
5. All of the treatments

Is used to determine the optimal allocation of a scarce capital.

Farms and paddocks are not homogeneous, different inputs are required for zone differential areas. The main focus is upon zone management that can maximise the profit potential leading to implementation of a solution.

All individual and combination treatments were shown to have a positive agronomic impact upon the farm enterprise. Through the improved yield and quality greater potential economic returns are generated. The difficulty from a farmer perspective is how to allocate their scarce capital to generate a maximum return.

Decision support modeling

A decision support model (IVC) was developed to test the application of investing in amelioration, varying the input rates or culling non-performing areas of the paddock to improve profitability.

Within the model there are a number of tables that require the user to input data to derive a result, tables consist of:

- A list of crop and stock options for the grains producing area of the agricultural zone. These detail the crop and stock income earning potential, they also detail the variable costs of all the options once the data has been inputted.

- A list of crop and stock option categories to derive a table of prepared gross margins. The gross margins cover a sequence of events over time. These form the control gross margins.
- The treatments that assist in improving profits are listed. For the zone within a paddock that a farmer chooses to treat it is necessary from trial results to apply, an application rate, the unit cost of the treatment and the effective life of the treatment to the zone. These extra returns are added to control gross margins to generate the optimal gross margins.

The model determines from the three broad objectives which decision option generates the greatest economic return:

1. Invest in amelioration (longer term inputs to ameliorate soil physical, chemical or biological decline);
2. Vary the rates of annual crop inputs based on potential productivity of paddock zones; and/or
3. Cull non-performing areas from the crop rotation (other uses or 'rest').

Results derived from the model were expressed as:

1. Paddock at control; and,
2. Paddock at optimum with or without paddock zoning.

These two results are expressed for each zone. The difference between the paddock at control and paddock at optimum are totaled to determine the net improvement. The net improvement is calculated in nominal dollar terms. No benefits over time accrued by any sequence of crop or stock rotations is used in the calculations.

Farmers when then invited to participate in using the process and the model. The first step in the process is to:

1. View aerial photos of the properties and chose areas to test using paddock history, yield maps and historical NDVI imagery etc.;
2. Armed with the knowledge of the property and the problems within paddocks such as soil acidity, determine which options are the most applicable; and
3. Run the model to test the treatments for the option.

The options that were available for farmers to test were fully costed and formed an integral part of the rotational gross margin. The rotational gross margin also considered the crop and stock options for up to a 20-year period calculated in nominal dollar terms.

The outputs were expressed as paddock at control, which is what the farmer was currently achieving. This was compared against the paddock at optimum, which is the paddock with zone specific treatments. The outputs were expressed in dollar terms indicating the treatment that generated the optimum dollar returns. Table 1.

Table 1. Control Vs Treatment

Optimum Result	**Zone 1**	**Zone 2**	**Zone 3**	**Total**
	All	**Lime**	**All**	
Whole Pdk @ Ctrl	-$632	$4,466	$1,141	$4,975
Pdk @ Optimum	$4,468	$10,090	$4,037	$18,595
Net Improvement				**$13,621**

Data for Table 1 was obtained in particular from spatial analysis of a well managed long-term trial conducted by Peter Sadler (Leahurst farms). This case study was based upon amelioration using lime in Zone 2 for the growing of barley. The inclusion of the other two zones required all treatments. The findings in this case study indicate that liming in zone 2 had the greatest impact and the treatments in zone 3 had the least impact. It can be deduced from the net improvement that it maybe worthwhile undertaking the changes to the paddock, altering the farm system using precision agriculture.

Benefits

Planning horizon

To be flexible there are both short-term and longer-term planning horizons. Treatment time frames vary due to response time of benefits accruing. The added benefit is that it allows treatments to be repeated across a range of crop and yield parameters. It is important that the longer-term consideration of sustainability by farmers be well thought through so that strategic planning and implementation occur, other than the view of ‘there is limited cash this year so we will defer such treatments’. If such treatments are not viable over the longer term then serious questions need to be asked if that part of the paddock should be farmed at all. “Fluctuations in farm incomes can affect the environment, for example in relation to investment in soil conservation measures, short term management practices aimed at maintaining financial viability, and level of flexibility for farmers to apply risk management strategies in advance of adverse climatic events such as floods and droughts.” (Carroll S 1999, 116).

It is within this section of the IVC model that more detailed calculations are occurring to indicate if a specific treatment or series of treatments maybe feasible over a longer time frame based upon a potential program. The rotational gross margin data then calculates a net present value and an internal rate of return. This better quantifies the difference to farmers based upon time horizons used and ensures that with the appropriate management better outcomes can be achieved. “The NPV depends upon the farmer’s planning horizon, and the farming system should be based on the net present value of the discounted net income.” (Shadbolt and Morriss 1999)

Table 3. Recommendation Table Peter Sadler.

	Current	Remedy	Difference	***Recommendation***
IRR		44%		
NPV / ha	$1,952.49	$2,330.26	$377.78	**Adopt Remedy**

The test data set (courtesy of Peter Sadler, Leahurst farms) was based upon a 17-year (with data from a long term trial run by the farmer himself) time frame calculating the net present value and the internal rate of return. The *Recommendation* column is an automated function that states to “Adopt Remedy” or “Continue Current Practice”. This function is based upon the remedy being greater than the current practice.

Risk

Zone management has used data from trials over the short, medium and longer-term time frames. This has assisted in providing data over a time frame beyond most short-term planning horizons. “Many of the indicators of farm business profitability are measures of historical or reasonably foreseeable future outcomes.” (Shadbolt and Morriss 1999) Trial data over lengthy time frames reduces the gaps in knowledge of researchers and the inherent unknown risk the impact trials and treatments have on the land. A part of that risk is that of financial failure.

Farm Finance

The financial viability of farm businesses is linked with considerations of physical resource use (Carroll S 1999). Minimising risk was a major consideration in the practices farmers adopted and the number one issue in this respect was farm profitability. (Shadbolt and Morriss 1999) For farmers to remain viable in the future it is important that they can remain competitive and can keep generating and sustaining profits over a long-term time frame. "Sustainable farming by definition is longer term." (Shadbolt and Morriss 1999) and "others have highlighted the profitability of an innovation as being a particularly important factor influencing its attractiveness to farmers. (Pannell D 2001) Zone management can be seen as a method where only the parts of a broad acre operation are treated which minimises the risk of financial failure. These treatments target specific problems reducing the perception of a cure-all.

Another factor relating to risk is that considered by financiers. With zone management financiers are better able to tailor packages and for insurance companies to minimise risk. This "would allow farmers and lenders to negotiate individually-tailored financial packages". (Brennan L 2000) Whilst there is no risk matrix associated with the program an opportunity index is under development.

Uptake of technologies

Use of a program that requires visual identification and data packages that can run paddock and zone simulations requires that managers spend more time planning and preparing whole farm programs. This type of planning maybe seen by farm managers as sophisticated and entrepreneurial. These maybe seen as a potentially negative and blockage to uptake however this has not been an issue to date with the program. There are 3 groups participating in the Central and Northern Wheatbelt participating in case studies evaluating the decision process. This uptake bodes well for the grains, cropping and grazing industries in the Agricultural Zone. "Entrepreneurial farms are associated positively with sophistication of business planning and sophisticated business planning is associated positively with farm performance." (Tanewski G 2000) The overriding key concept is to have user friendly packages that can be used simply with a minimal amount of time generating powerful outputs.

Opportunity Index

An opportunity index is currently under collaborative development. The main impetus has come from the University of Sydney, it is seeking to better quantify the environmental consideration. An opportunity index aids the decision making process of farm managers. Alex McBratney stated; the larger the output from the index probably indicates an excellent opportunity for precision management. The opportunity for site specific crop management can be regarded as a function of a magnitude of a yield variation component, an area of management component, and economic/environmental concerns. The area of E in the equation is still problematic.

$$OI=\sqrt{((\text{auto-arcovar}_{1000}) \div \text{Median}(\text{auto-arcovar}_{1000}))} \times ((pT \times A+(1-pT) \times J_a) \div MZEM) \times E$$

Magnitude Area Economics/Environment

The opportunity index is measuring the opportunity cost beyond pure agronomics, economics and seeks to incorporate the environment. The difficulty arises in accounting for the environment. Dr Schilizzi states the problem succinctly; how are we to know how much of an investment is environmentally related. McBratney *et al* has these same concerns.

The accounting for the environment remains the biggest challenge and appears set to evolve with the methodology of accounting for the environment.

The opportunity index determines the magnitude of variation (magnitude). It determines the spatial distribution of yield variation or the operational area for machinery. Lastly and under development is the consideration of the economics and environments. For a more detailed explanation of the index please refer to the paper titled A management opportunity index for precision agriculture.

This index would assist the IVC model by deriving a determination factor for precision agriculture based on the spatial and magnitude distribution of the paddock variance.

Conclusion

The Invest, Vary or Cull program is a decision support model that is assisting farmers in exploring possible economic options for infield biophysical constraints. The model has the capacity to take into account the short to long term economic benefits and aids in the decision making process.

The process of developing an opportunity index will assist decision making on whether to change how paddocks are managed.

Both the IVC and opportunity index will drive change, change to the farming systems. Paddocks will no longer be treated as homogenous where maxi-pack products are used. With assistance from technology parts of paddocks will be zoned off and inputs will be tailored to suit the specific requirements.

Case studies undertaken by groups and individuals investigating options for poorer performing paddocks have demonstrated that precision farming provides economic advantages. Response actions have occur to ensure that the management of these paddocks changed to optimise the yield and quality of produce from the inputs applied to achieve higher input/output ratios across the zones within the paddocks.

If through the exploration of known agronomic problems and solutions that we are able to increase profits through the adoption of the most profitable solutions. Over time the likely hood of farmers who have had a positive experience will be more likely to participate and adopt new or innovative practices into the future.

With an industry that is more reliant upon crop income, mechanisation and selected use of livestock, the issue of developing a farming system, which will remain sustainable, is of the utmost importance.

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Collar

References

Blake J (2001) Progress Report 21. GRDC DAW633 Future Management of Poorer Performing Paddocks. P 2

Blake J et al (2002) Invest, Vary or Cull in Precision Agriculture Crop. GRDC DAW633 Future Management of Poorer Performing Paddocks. P 1

Blake J and Peltzer S (2002) Impact of claying on grass weed management and profitability. Proceedings of the Thirteenth Australian Weeds Conference Pp717-718

Brennan L, Carberry P, and Hochman Z (2000) Can information better use information on climate variability? Australian Agri-Food 2000 Research Forum Pp1-2

Carroll S and Morriss S (1999) Sustainable Agricultural Initiatives in New Zealand. Proceedings of the 12th International Farm Management Congress Pp105-116

Cook S et al 1996 Precision Agriculture and Risk Analysis: An Australian example. Precision Agriculture Proceedings of the 3rd International Conference. Minneapolis, Minnesota. P1223.

McBratney A (2001) Precision Farming Forum. Precision agriculture in Australia. P4

McBratney (2000) A management opportunity index for precision agriculture. Proceedings from the 5th International Conference on Precision Agriculture.

Pannell D (2001) Dryland salinity: economic, scientific, social and policy dimensions. The Australian Journal of Agriculture and Resource Economics. P526

Peek C and Rogers D (2002) Economic comparison of farming systems for the medium rainfall northern sand plain. Proceedings of the 2002 Crop Updates P41

Robotham, B 2000 Australian Sugar Convention Proceedings Handbook. P95

Schilizzi S (2002) Triple bottom line accounting: How serious is it? School of Agricultural and Resource Economics, University of Western Australia. P1

Shadbolt N and Morriss S (1999) Financial indicators of sustainability for farming businesses and families: A conceptual model to relate these indicators to those used for environmental and social sustainability. Journal of international farm management. P53, 54, 58, 59

Tanewski G, *et al* (2002) Owner characteristics and business planning as determines of Australian family farm performance. Australian Agri-Food 2000 Research Forum Pp4-5