Precision Agriculture

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1999 Nuffield Scholar

Sponsored by: GRDC and Qantas

Acknowledgements:

Being awarded a Nuffield Scholarship was at first a very daunting task. My family and fellow Nuffielders were saying that this is a once in a lifetime experience and they all gave full support to me. There is no doubt that the strongest supporters who made this all happen were my wife and children and my parents.

Whilst I was away exploring the world they all rallied together and kept the home fires burning and the business running as per normal. For my wife and children to spend the second 12 week period of my trip with me travelling around the world was making it very pleasurable for learning and meeting new people and places and to still have the people that mean the most to me right by my side.

I am very grateful to the GRDC and Qantas for their very generous sponsorship and full support in the developmental stages of my tour helping with planning and the general set-up of the tour.

Fellow Nuffielders that I travelled with along the way certainly made difficult times being away from my family and business very enjoyable and friendships were developed that will last a lifetime.

The people that showed my family and me the great hospitality along the way are the real reasons why the Nuffield experience works so well and I only hope that I can return the favour to them some day.

I was lucky enough to win a placement at the Wye College this year and I must thank some of our personal suppliers to our business for their help with sponsorship. They were:- Woolman Petroleum
Iama, Horsham
Pivot Limited

The Nuffield foundation plays a big role, both in support at a financial level and also at a moral support level, that will never be forgotten. I am indebted to everybody involved in the foundation and only hope that I can become an acquaintance with this great group of people both here in Australia and overseas.

Introduction:

My objective was to study the possibilities that precision farming may be able to take us to a higher level of productivity and profitability with current farming systems used here in Australia. Inputs were the target area of concern where the shifting of certain inputs within the paddock would result in a higher profit margin. Other benefits that may be considered would be the reduction of risk to the environment with the high input farming that we seem to be in at the moment.

A key benefit when developing a strategy for the application of precision agriculture for one's own farm is the understanding and knowledge gained about the soil environment with which one has to work.

Generally speaking anybody who makes the decision to go down the precision agriculture path has to be committed to having some failures and also has to be committed to making it a long-term project that may not see any extra dollars gained for a few years. There are three main areas of this topic that can be looked at individually, that being:- Data Collection
Decision Making
Variable Application

All other aspects of production must be in place such as good weed control and good nutrition before anybody should attempt the precision farming technology.
A general comment that was the same all over the world is that the technology in the machinery, hardware and software is way ahead of the agronomy to make it all work and there needs to be more research done in this area.

Yield Mapping:

For a well-managed farm that is looking for the first place to enter into the precision farming technology, yield mapping is a good place to start. This would be the most cost effective place to start with some immediate benefits that could have a dollar return straight away.
These could include:

- Helping with crop selection with comparison of yield to input cost.
- Identify poor yield areas that may be better off not cropped at all.
- Evaluating different crop husbandry decisions and various trial works that you may carry out.
- Target problem areas for crop monitoring during the year.
- Providing evidence for a compensation claim of chemical over spray.
- Identifying areas that may be harvested and stored separately for quality problems.
- Drainage areas that may need improvement from waterlogging.
- Resistant weed areas that need further investigation.

Yield maps are probably the easiest way of gathering and processing information in this new technology. A good level of computer skill needs to be had or gained to produce these maps as some of the software available is a little confusing but the software today is a lot more user friendly than what was available 4 years ago.

It seems that if you are going to use your yield maps to try to devise an application map for fertilisers without using any soil testing, it could take a long time to develop a correct equation to use. Generally it would take at least 5-6 years of data information from yield maps before you can see some trends occurring in each paddock. In those years where the rainfall is outside the average rainfall by 15 % above or below the maps are generally going to be inaccurate as far as nutrition goes. If every year's rainfall was the same the maps could be used to make some good conclusions. Those years with rainfall measured to be within that 15% above or below will give you the best results. This is because the variability of moisture being too much or to little does not have a big influence on the yield. It seems that in the years where the moisture is not influential soil nutrition can be measured as being high nutrition status in the low yielding areas and low nutrition status on the high yielding areas.

Using the yield maps generated to devise zone areas for investigation is the best way of determining the nutrient status of the soil. Making three different zones being high, medium and low yielding seems to be the most popular and cheaper option rather than going to a full grid sampling regime for soil testing.

With most of the modern yield mapping machines available today, they have the ability to produce a weed map on the go with the driver of the combine simply pushing a button every time the machine goes through a heavily weed infested patch of the paddock. At the end of the day a weed map can be generated as well as a yield map. This is a very good source of information because it does not need any interpretation because the infested areas are easily identifiable and can be treated accordingly with the pesticide the next year if you have the right application gear on the spray unit.

All yield maps have the capability to produce an elevation map, which is not that accurate but can give some good information on elevation difference of 3 metres or more. A capital cost of around $8000 is required for the actual yield mapping system in the combine plus another $6000 for the G.P.S and then a further $2500 for a 12-month subscription to a D.G.P.S supplier. This does seem an expensive up front cost but most people who buy the system on a new combine will say that they have covered the cost of owning the system by the time the machine is ready to be traded in and the new machine will always have a yield mapping system fitted.

In Canada and the U.K the uptake of the yield mapping equipment has slowed down dramatically because the next generation of farmers entering into this market seem a little concerned in the value of the information gained. I think that this next generation of farmers entering into the yield-mapping scene are concerned about how to manage this new technology. With the average age of farmers around the world sitting at about 55 to 60 years of age the understanding of G.P.S, computers and soil environments are a bit beyond them. I feel this is a bit of a concern because for the price of the equipment to go down there needs to be more people using the technology.

A code of practice for accurate yield maps.

For the new players in the yield mapping game there are certain things that must be adhered to prior to using this equipment. Here are a few things to do and problems that may occur.

1. For different crop types and different grain weight the time setting for the grain to travel from the cutter bar to the grain flow sensor could vary and needs to be adjusted accordingly.

2. A change in driver of the machine could lead to incorrect maps being produced. A simple example would that be if one driver was driving a little wider than the other, the end result would be that the paddock would have more total hectares and the yield per hectare would increase for the driver who was driving wide.

3. When harvesting high moisture grain or oilseeds in damp conditions, the flow sensor will collect a residue, which will build up and give a false reading. Many operators do not check this sensor and find the crop yield decreasing as they get further into the paddock.

4. Try to limit the amount of narrow finishes in the middle of a paddock. This can be done by simply working from side of the paddock to the other and try to keep the runs as long as possible. The fewer headlands in the paddock the better the resulting yield map will be.

5. Limit the amount of stops midway through the run because what happens is there will be a reading at the place that you stop of three or four times the actual amount that the crop is yielding. This reading will go into the average for the area and there fore could give a high yielding area when it is not really yielding that well at all.

6. If lodging is occurring in the crop the time for the grain to move through the machine will be longer and could also give an incorrect reading. If the lodging is only in one particular part of the paddock it may be worthwhile harvesting it separately rather than speeding up and then slowing down.

7. At the end of each pass try to lift the front platform in a uniform speed and keep the timing of the lifting procedure as close to the end of the crop as possible. This will minimise the headland at the end of each run.

8. When harvesting windrowed crops it is important that the windrower is always taking a full cut and the amount of material in the windrow should be as constant as possible not only for the yield mapping but for general header performance as well.

9. When harvesting around curves incorrect readings can be produced because the wheel sensor is mounted on the side of the machine, which going one way will give a high reading and then the other way will give a lower reading. This will happen if you harvest around the paddock leaving the headland to last. It will seem the actual headlands are higher or lower yielding than the rest of the paddock depending on which side the sensor is mounted.

Soil Sampling

There is no doubt that the best way to find the nutrient status of the soil is to do a grid sample on each paddock on a one-hectare basis. This is the most expensive way to find out this type of information. It is not justifiable to purchase this type of information on the broad acre type of farming. With the cost of doing the analysis of each sample being around $35 to $40 it is not feasible to think that a lift in profitability would cover the cost of this practice. In the high input cost of say an industry like horticulture the benefits would be there because if they have a input cost of around $2500.00 per hectare and they make a 10% reduction in costs that is a huge saving and can go a long way to paying for equipment or the extra expense of grid soil sampling.

In the broad acre cropping areas it seems the most popular way to determine the nutrient status of the soil is to divide each paddock up into zones of high, medium and low yielding areas from the yield maps produced. Along with these zones the elevation of the soil should also be taken into consideration. Once again three different levels or zones should be created, these being high, midslope and low level. If you have two zones in the paddock yielding the same and they are on a different elevation levels it is quite likely that the soil characteristics will be different and the water holding ability will be different as well so it is best to keep these samples separate.

When developing these zones it is important to remember these zones should be kept the same each year. If the following year has a different rainfall pattern it is quite likely that a new set of zones will be developed. It is best to use the zones created in a year which has less than 15 % above or below the average rainfall as the yardstick. These years are the most important ones to gather the information if you only want to do samples once in four or five years.

It must be remembered that every farm is different and within that farm every square meter of soil is different as well, so it is very hard to get a system that works well on each farm without some problems being encountered along the way. Each farmer should develop his or her own guidelines to follow and they may not work on the farm down the road. Once again it is this extra workload created by this type of technology that only allows those farmers who are well organised and have all other aspects of production under control to tackle this type of farming.

Soil samples may seem expensive at the time of collection but it must be remembered that the soil test should give you the necessary information for the following five years. This is so because it is unlikely that the soil will change its characteristics in that amount of time. So when budgeting comes, the cost of the soil test should be spread over 4 or 5 years.

In the developmental stages of setting up zones another useful tool is the aerial photo, which can reveal different soil types simply by the colour alteration in the image. It is highly likely that the soil difference will be attributed to colour and generally yield may well follow the soil texture.
Farmers knowledge of his/her own paddocks is by far most important with the development of zones and most farmers will be able to look at a aerial image or a yield map and say if a particular area is usually high or low yielding.

Too often the soil samples that are taken are only as good as the physical gathering of the samples, which sometimes leave a lot to be desired. This part of the process is critical to the end results and more often than not lead to indifferent results which in turn leads to a misunderstanding of what is really going on.

Interpretation of soil test results is also another area that needs to be focused on and most soil test laboratories have field staff to help make correlations between results and yield maps. This time spent with the field staff is invaluable in the development of an application map for nutrients.

Variable Rate Application

The principles of variable rate application are nothing new to farmers of today. Previously many farmers would apply lime or gypsum variably across the field simply using general knowledge of the different soil types that exist in each paddock. A simple movement of a hydraulic lever would change the rate of lime from one tonne to the hectare to two tonnes to the hectare. In essence this technology is the same except the rates and the changes of the rates are worked out in the office and then put onto a PCMMIA card (small floppy disc) and then transferred to a computer mounted in the tractor and the hardware installed will do the rest.

Hardware for the variable applicators has pretty well got the problems sorted out and the problems that most people are having are to do with the software side of things. Air seeders that are fitted with variable hydraulic drives have been around for sometime now and most of the new air seeders on the market are going away from the chain drive set-up and are using hydraulics instead. This will dramatically bring down the cost of switching over to a variable rate seeder that can alter the seed and fertiliser rate across the paddock. At this stage there is a patent on the applicators that can do seed and fertiliser together, as a result of this only seed or fertiliser can be altered at one time at the moment. Early users of these applicators did express some difficulties with getting the applicators to be accurate in applying the right amount of material in the right place.

For the developmental stages of this technology the machinery manufacturers were supplying a lot of back up service and direction for farmer. Of late it seems that these manufacturers are finding it very time consuming in getting the equations for application right and therefore are letting the researchers and the farmers work it out for themselves. As I stated before this type of technology has to be worked out by the individual and your own set of rules need to be developed for your own farm.
Most of the variable rate software has the capabilities to apply the input at many different rates across the paddock but it is generally advised that you keep things reasonably simple and only have between 4 and 6 different application rates in each paddock.

In my travels I did come across some people who compared the variable rate application of fertiliser with the original practices that the farmer was currently using. Because the equation for the variable rate was incorrect there was a negative effect on the profitability of that part of the paddock. That is not taking into consideration the cost of the hardware needed to variably apply that particular input.

Visiting the Silsoe research centre and talking to Professor Paul Miller put a new light on this subject. My thoughts of spending the money on the expensive variable applicators on the air seeders was some what short lived when his idea of putting the

variable rate applicator on the boomspray were explained to me. It is very difficult and can take a lot of time to work out the nutritional aspects of the soil. By putting the applicator on the boomspray you can get instant reductions in pesticides because you do not have to analyse anything. All you have to do is gather a weed map from the yield monitor or simply scout the paddock on an ATV with the correct software and there you have it, an instant application map for any particular pesticide. Not only can you use the boomspray for variably applying pesticides but with the introduction of liquid fertilisers you also do that with the same equipment. His idea would be, apply a variable rate of say phosphorus for example, and then when it comes to seeding you would apply much lower blanket coverage of phosphorus.

This kind of equipment is probably the most expensive part of precision farming and I did not come across one farmer who actually said that this equipment has paid for itself, as did the yield mapping equipment

One farmer I spoke to in Saskatchewan has had a Flexicoil system for four years and explained how the variability in seasonal rainfall was not allowing him to get the equation right. He also said the safest way of using the equipment without doing any harm to the current crop was to simply replace the nutrients that were taken out by the previous crop but the problem with this is that you never really see a big benefit from this practice and you would never recoup the cost of the equipment. To overcome the cost of the equipment, a few people were offering the equipment to other farmers on a custom application basis to spread the cost over more acres. It seems to me that this may have to be the way to enter into this technology here in Australia, with farmers here finding it hard to make ends meet with the our current economic climate.

Vehicle Guidance:

There are a lot of different uses for the vehicle guidance side of this technology but the most widely used and cost effective use is for spraying of pesticides. It has become common practise these days for the aerial contractor to have a G.P.S guidance system installed. To a lesser extent is this technology used by farmers on their own ground rigs. Many of the custom applicators are using guidance these days because they can spread the cost of the equipment over many hectares.

Some of the benefits of using guidance for spraying are well worth considering when purchasing the next spray rig. Most importantly is the reduction in the amount of pesticide used, for economic and environmental reasons as well. It has been measured that the reduction in actual hectares covered in any one paddock is usually about 1 or 2% less, this is because there is not as much overlap, this overlap factor without using guidance can have a double whammy effect on the profitability at the end of the day because not only are you spending more money on chemical but the overlapped part at the end of the boom will have a reduction in yield because of over application. This also has a positive effect on the environment as well with less over application of chemicals.

With spraying conditions very limited with the weather playing a big role in the amount of time a spray rig can be actually working in the field, it can be a benefit to do some spraying into the evening. Depending on what pesticide you are using it can be beneficial to do the spraying in the evening because usually conditions will calm down at that time of the day.

If a farmer or spray contractor is spraying out 4 or 5 tanks of chemical each day and if it is possible to get one more tank done each day that could amount to a 20 % increase in use of that one machine. For a contractor, that could be the difference between making a profit or a loss in the business.
With most of the guidance systems there is a steep learning curve for the operator to get used to the equipment. Talking to people that do operate this equipment it would take at least a week to become accustomed to this new way of spraying.

Obviously there is still the human error built in to the use of most guidance systems but there is a lot of companies trailing an auto steer version. This will take out the human error factor and would be much more accurate with the purchase of a better GPS system. Some of these systems are getting down to 2 – 3 cm accuracy. To have this sort of accuracy the cost of the system could be as high as $70000 to $80000, this is obviously not for the broad acre farmer. In the high value industries like horticulture or cotton industries this type of set-up would have a place for the farmer, or more likely the contractor.

With the age in which we live, there is always a place for litigation, and it is very useful having a guidance system, which will recall all the spraying days' weather conditions. Having a map produced at the end of the day is proof to the farmer of the job that has been completed by the contractor and has been up to the expectations required.

A side benefit to having this equipment is the ability to look at the job being done as you are progressing through the paddock. If for some reason there is a missed section caused from a human error you can go back to that particular area and correct the mistake if need be. Very often missed or unsprayed strips in the paddock are the place that the weed infestation will start from the following year. There is no doubt the best way to stop heavy weed infestations is to stop seed set and if you let that seed mature from a missed strip in the paddock you could end up with a generation of weeds there that might take between 4 and 5 years to germinate.

With the boom sprays growing in width these days it nearly impossible to drive a 30 metre wide machine fitted with a foam marker to an accuracy of 20 cm which is what is achievable with the guidance systems of today. Foam markers are fine in the right conditions but with a little wind and in high crop they are not the answer. Many farmers today would put more chemical through one machine in one year than what the actual sprayer is worth. To be wasting this expensive pesticide is not only bad on the environment but is also hard on the hip pocket.

Summary

There is no doubt that the adoption of Precision Farming in the past two years has slowed to a certain extent because the early adopters of this kind of farming have hit a bit of a brick wall concerning what to do next.

For a start, it seemed that machinery, fertiliser and chemical companies got on the band wagon to promote ways their company could help farmers to gain healthy profits and reduce costs. But with the complex nature of the soil and climate variations it was difficult for them to come up with a standard set of rules that would cover every paddock on every farm.

The U.S seem to be making more headway with this technology because the farmers are guaranteed a more stable income and are then willing to spend extra dollars on trial and error research. I am sure that when Australian and Canadian farmers are on a level playing field with the U.S farmer, we can start researching this type of technology more thoroughly again.

On the research side, we are not that far behind the U.S., but the uptake of the new technology is slow. Unfortunately for the price to come down more people need to adopt this way of farming thus creating competition between the producers of equipment that is necessary for this technology. Another factor that is slowing the uptake of this technology is that the average age of farmers in Australia and Canada is 55 years old. At this age there are limited few who are interested in this technology. Because there are so many variables in trying to work out what works for each farm there is a market for a young mind to supply farmers with a service of getting from a simple yield map right through to an application formula for the next seasons crop. The only downfall the young mind must have a reasonable education and should be able to charge $50.00 per hour his/her skill level. Because Precision Farming is so time consuming it is not a viable option for farmers to have someone work out the entire operation and still make a profit on the farm at the end of the day.

A lot of the research places I went to had the equipment donated. It was still hard for them to prove at the end of the day there were big profits to be made. With the overhead cost of all of the machinery and to variably apply inputs the average farmer will not recoup the cost in 5-6 year period. The people who can make this equipment pay are the people who are spreading the cost of machinery over a bigger land base area by contracting their services out. It is still hard for contractors to justify time spent on research because eventually the farmer does not want to have to pay somebody the $50 per hour for the research side of things.

Precision Farming is going well in the high input cropping systems such as the horticultural industry. They have such high input costs that if they can save 10% on the cost side of things it would equal the profit of a broad acre farmer's whole paddock. So there is certainly a positive attitude amongst these high input-cropping farmers towards Precision Farming.

Finally I would like to say that if a farmer is willing to stick to the task of continually learning about the food that we produce and ways of making a profit, at the end of the day without harming our most valuable asset – the environment, precision technology has a place in the future of our industry.