

PRECISION FARMING ON THE FARM

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INTRODUCTION

Precision farming (PF) has become a catch-all term broadly applied to farming procedures that use electronic devices, particularly DGPS receivers. These techniques may be either more or less precise than the older methods they are augmenting or replacing. The promises of precision farming technology remain largely unfulfilled for a number of reasons. A successful farm implementation of precision farming methods starts with well defined objectives. Farmers are advised to individualize their definition of precision farming based on their objectives, expectations and availability of specialized equipment before entering the precision farming arena.

The implementation of a full suite of precision farming methods may easily be the most exhilarating experience of a farmer's career. Or it may be a shipwreck. The implementation plan will determine the outcome. "Before you begin, have the end in sight".¹

BASIC TECHNIQUES

Steering guidance

A useful introduction to these methods can be had by first gaining experience with a steering guidance system employing a standard DGPS receiver. Experience with a guidance device will verify the performance of a DGPS receiver at your location on your farm. It may also demonstrate the technique is less precise than a well designed mechanical marker for specific field operations. It's essentially a trade-off with large potential benefits under low visibility conditions but less precise and accurate than its mechanical brother under ideal field conditions. Convenience and reliability are also part of the consideration. Results vary with the equipment operator and location. In general, the user satisfaction level is higher when the technique is applied to spraying procedures rather than seeding operations because operators are less tolerant of steering errors in seeding procedures.

Field coverage mapping

Field mapping is a logical second step. This procedure can be implemented at minimal cost since the mapping device is able to use the positional information from the DGPS receiver that is part of the guidance unit. In some cases this feature is built into the DGPS guidance package. This entry level mapping procedure creates field coverage files that can be downloaded into a computer program where maps can be displayed and printed. Field coverage maps are beneficial when performing custom applications and may be valuable in complying with future environmental management regulations. The negative consequences of a failed mapping procedure are minimal.

Yield mapping

Unfortunately the benefits of yield mapping were initially oversold by some equipment purveyors and this resulted in a negative bias towards PF systems. It was supposed to be simple. Several years of yield maps were first collected as the starting point. Then one simply took the yield files to a local service provider that processed the files on a computer. The computer kicked out a site specific fertilizer prescription for each field onto the same memory card. Next the memory card was inserted in the computerized task controller in the fertilizer applicator and the variable rate applications were made according to a magical prescription. Of course this never happened in a significant way in dryland cropping systems in the Central Great Plains of North America. The method didn't generally work. Many farmers abandoned yield mapping procedures because they saw it as nothing more than an additional expense.

Examining the other side of the coin it is evident that yield maps can be of great value if they are used to measure the effects of different management practices. In fact accurate yield maps are the only cost-effective solution to measuring the site specific economic benefit of experimental management practices on a field scale.

Yield map results are a function of the yield mapping system, operator skills, combine characteristics, operating conditions and the software techniques used to generate the maps. When the mapping procedures are under control it's time to get on with the real mother load of PF methods.

SITE SPECIFIC MANAGMENT

Background

The ability to manage field applications in small physical management units provides an opportunity to use field inputs more efficiently, particularly fertilizers. An appropriate focus suited to the black soil zone in Western Canadian cropping systems is the site specific management of nitrogen fertilizers. The nitrogen supplying ability of soil has been shown to vary widely within individual fields. Crop yields have easily been demonstrated to be more responsive to nitrogen than other macro nutrients. Furthermore, nitrogen fertilizer is typically one of the largest single input costs in small grains production.

It is interesting to note that basic site specific management methods predate the use of inorganic fertilizer. In earlier times organic fertilizer in the form of manure was regularly applied on a site specific basis. Today, complex technologies suited to farming broad expanses are being employed in attempts to achieve a similar result.

According to soil scientist Dr. Dan Pennock, "Site-specific management has turned out to be a lot more site-specific than researchers originally thought".² Don't lose sight of this fact.

Site specific nitrogen fertility management

Implementations of site specific nitrogen fertility management typically involve variable rate (VR) nitrogen applications. Variable rate fertilization (VRF) methods have received considerable attention in the research community however few effective solutions to VRF implementation have been identified.

Initially, investigations focussed on grid soil testing methods and in some jurisdictions this practice has gained a level of acceptance. More definitive investigations have concluded the grids must be very small to obtain a useful result.

Remote sensing methods using imagery from various sources have been promoted for many years. These methods have produced inconsistent results and do not appear to be an adequate solution for VR nitrogen application in the black soil zone. Experimental implementations of these methods on farms in the Melfort area failed to produce a profitable outcome.

Nitrogen fertilizer recommendations

It is well established that the common nitrate soil test does not provide a reliable estimate of the overall nitrogen supplying ability of the soil. VR nitrogen applications based on nitrate test values are unlikely to have a profitable outcome.

Extensive field scale testing at Melfort indicates that if the nitrate test is used as the sole indicator of soil nitrogen supply, the errors may readily exceed 500%. In fact the nitrate test by itself may be more misleading than it is informative.⁴

The largest source of plant nitrogen in black soils may be from the microbial degradation of soil organic matter rather than residual soil nitrate or applied fertilizer. This process, called mineralization, can be predicted through laboratory analysis although the test procedures are not mainstream at this time. Soil mineralization estimates are essential if the objective is to arrive at successful VR nitrogen management endpoints by technical means and at a cost that is affordable.

The farm encyclopedia

Farmers are attracted by new technology that is accompanied by exotic claims. Living in the era of advanced technology it's easy to forget that the ultimate farming encyclopedia is the one we carry around on our shoulders every day. The dimension of this encyclopedia is unmatched. Its resources are readily available anytime, anywhere. It doesn't require costly upgrades like the computer software we use. It can make decisions in a split second without electricity.

It is clear the farmer's encyclopedia contains much detailed historical information about each individual field on a farm. Mental images or virtual maps³ of fields stored in the farm encyclopedia are very helpful in arriving at site specific fertilizer recommendations.

THE Pro-VRF METHOD

Pro-VRF defined

The Pro-VRF method of implementing variable rate nitrogen fertilizer applications starts with a professional farmer and a professional agrologist defining the objectives for the management practice. Risk tolerance and technical parameters are related to the objectives to arrive at a framework for the implementation.

A full implementation of Pro-VRF requires a variable rate fertilizer controller, a task controller that is capable of recording actual rates of fertilizer application and field position in a computer file, and a DGPS receiver to determine the field position. The Pro-VRF method was developed

using a Dickey-John Land Manager II rate controller, an Ag Leader PF3000 task controller and an Outback S steering guide for the DGPS position information. A plan for processing the computer files generated during fertilizer applications is key to reaching the final endpoint of doing all VRF nitrogen applications according to a site specific prescription. It is advisable to ensure that either the agrologist or other service provider has all the software and software skills necessary to carry out these procedures before starting the VRF implementation process.

The technical component begins with a detailed soil testing plan. Advanced nitrogen soil testing methods are required to arrive at site specific nitrogen recommendations and this part of the plan should be completed with the full participation of the farmer. There is no known technical method of duplicating the field knowledge base of an experienced farmer, at least at a cost that is bearable.

On the basis of the soil test data and the farmer's field knowledge, a variable rate application plan is developed with the agrologist before beginning field applications. At initial startup it is helpful to place a few color coded flags in the field as reminders of where certain rates should be applied. During year one the fertilization rate is varied manually during the field application and the rate patterns generated during the application are recorded in the computer file by the task controller. The patterns are extracted from the file using advanced GIS software and form the basis for a prescription that is used to automatically control the application rates in subsequent years.

The VRF recommendations for following years are arrived at through a reduced soil testing program and the recommendations are tailored to prevailing soil conditions and the objectives and preferences of the individual farmer. Customization and editing of the prescription recommendation file in future years is limited only by the skills of the service provider.

How well will the Pro-VRF method work on my farm?

It is important to measure the outcome of the Pro-VRF implementation in terms that are related to profitability, typically fertilizer cost, crop yield and quality. What is required to get an estimate of the effect on field profitability? Not much beyond a few markers in the field and a couple of extra trips to a scale to weigh the grain from the strip trials in the field.

Grain should be weighed from 3 separate strips in the field. One strip should receive a zero or very low rate nitrogen application, one should have a fixed rate application and the remainder of the field would have a variable rate nitrogen application. The strips should be long, narrow and easily identified during harvest operations.

Ideally, a yield mapping system is used during harvesting to obtain site specific yield information. A high quality yield map allows for much more detail in assessing the results of the variable rate fertilizer application. If a yield map is available, surface interpolation methods can be used to compare the amount of fertilizer applied to the yield in individual logical management units (LMUs), as many as 50 LMUs¹ per acre. Again, as with the fertilizer 'as applied' files, it is important that a service provider with the necessary software and computer skills is available to process the yield files and analyze the results. The use of small LMUs gives high positional resolution in the field and provides a very large data set that is well suited to statistical analysis.

Will Pro-VRF reduce the greenhouse gas emissions on my farm?

The greenhouse gas of primary interest in crop production systems is nitrous oxide as it is 310 times as harmful to the atmosphere as carbon dioxide. Carbon dioxide field emissions are of limited concern in direct seeding continuous cropping systems. It has been estimated that a 30 % decrease in the use of nitrogen fertilizer in North America would result in an 80 % reduction in nitrous oxide emissions from crop production systems.

These emissions rise sharply when the soil nitrogen supply exceeds the crop requirements. It is obvious that a proper implementation of VRF nitrogen will tend to lower these emissions. While results will vary, about one third of a field will be over-fertilized if a fixed rate is applied. Clearly VRF methods are a critical component in the reduction of greenhouse gases emissions from cropping systems and this practice has been given a high priority in official United States Department of Agriculture recommendations for reducing greenhouse gas emissions in cropping systems. Soil nitrous oxide emission data has been collected across Canada in recent years to establish baseline values. In consideration of the Kyoto Protocol guidelines, it is clear that nitrogen fertilizer use restrictions may be the most serious regulatory constraint placed on grain farmers as the Kyoto principles are implemented in Canada.

CONCLUSIONS

In view of the mammoth exemption from Kyoto principles that has been granted to the automotive manufacturing industry in Central and Eastern Canada, it may be comforting to speculate that farmers in Western Canada will be granted an exempt status as well. There is little evidence to support the notion that a general exemption for farmers is even a matter of consideration.

Site specific nitrogen fertilizer management using variable rate fertilization methods such as Pro-VRF is one of the most promising applications of precision farming systems in small grains cropping systems. Beyond the improvements in profitability that it affords, it is the only facet of precision farming that has the potential to greatly reduce greenhouse gas emissions in field crop production. As such, it is likely to become an essential practice as the new Kyoto Protocol regulatory environment unfolds.

Farmers require VRF implementations that are available off the shelf. Partial solutions to VRF are to be avoided unless a farm has the infrastructure to take on the role of a developer. Resource requirements skyrocket when crossing the line that separates a 'user' of the technology from a 'developer' of the technology.

Numerous methods of VRF implementations have previously been devised and marketed with much gusto. These methods have generally failed to achieve the desired results in small grains cropping systems in the Central Great Plains Region. Farmers are advised to approach any 'pushbutton' method of implementing VRF with a great deal of caution.

The Pro-VRF method has been successfully used to implement variable rate nitrogen fertilizer applications on a whole-farm scale and may be the method of choice at this time for farmers in the black soil zone of Western Canada.

The addition of autosteer guidance technology to the Pro-VRF method will improve the result and facilitate the implementation. This is one of several Pro-VRF enhancements that are currently under consideration.

REFERENCES

1. McIntosh, Dennis, 2001. Use instinct and experience to develop logical management units. *In Farming Magazine*, Volume 4, No. 4. pp 14 - 16.
2. Pennock, Dan, 2001. State of the art and where are we going with site specific management: A scientific perspective. *In 2001 Site Specific Management Conference Proceedings*. Edmonton, AB. pp 154 - 159.
3. McIntosh, Dennis, 2001. Seat of the pants (SOTP) methods. *In 2001 Site Specific Management Conference Proceedings*. Edmonton, AB. pp 130 - 133.
4. McIntosh, Dennis, 2001. On-farm example of GIS use. *In 2001 Site Specific Management Conference Proceedings*. Edmonton, AB. pp 166 - 171.