PRECISION FARMING IN THE 1990'S. A FARMER'S PERSPECTIVE

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Much has been written in the past year about agriculture and the fourth revolution. Mechanization, fertilization, seed hybridization and agriculture chemicals have shaped and formed agriculture as we know it. The information revolution will become the agriculture's most productive and challenging revolution yet. Farmers have long recognized that their fields are not homogenous units. They vary in natural and manager induced characteristics and at one time managed accordingly. In the past, agronomic production tools have been developed to manage ever larger fields as homogenous units and the ability to respond to variations within those fields has diminished. Computer and electronic advances will enable farmers to produce their crops more efficiently and with less damage to the environment by managing land in units much smaller than a field. The technology is called site-specific farming (SSF).

New tools

In the very near future, as we purchase new tractors and/or combines these implements will have built in computers. These computers might be as common on the farm as a socket set is today. But it's unrealistic to expect every farmer to be a computer user-unless you assume only computer-using farmers will survive. In a recent article in "Resources" a publication of the American Society of Agricultural Engineers, stated "Most estimates indicate about 40% of farmers own computers. No one really knows how may farmers actually use these computers, or how much". Never the less, today's computer technology comes closer to delivering on promises we farmers perceived over 12 years ago in the infancy of the farm computer age.

Computer platform

Today we perceive the computer technology as our bridge to the future. But if farmers are not familiar with computer usage, the opportunities of this new technology will not be realized. But with adequate working knowledge, the computer has the potential to change how and why we farm.

Early adapters of the computer has found it easier to accept and expand the use of site-specific technology on the farm. These first wave innovators had to learn both the computer and the precision farming methods by the seat of their pants. Most of these farmers integrated hardware and software themselves, or found sources for help.

The next wave of adapters tend to want someone else to run the technology. Their perception is they don't have time or the inclination to perform the required technical computer analysis. The next wave farmers must realize this technology and analysis is no better than the person behind the keyboard of the computer. "Perhaps these next wave farmers want the inspiration without the perspiration." Grant Mangold

New technology?

The newly acquired technology agriculture is now discovering is not new at all. GPS, GIS, remote sensors (satellite and on-the-go) has been used by other industries, especially the military, for nearly two decades. These industries has benefited from the use of these tools greatly. Because of cut back on military spending in the U.S., these other industries had to stretch their horizons to keep their companies viable and agriculture is the beneficiary.

Another reason outside sources perceive this technology as a "god send" are the "farm regulators". The environmental movement today is a driving force behind many governmental decisions. If agriculture is not careful, this new technology could be the undoing of farming as we know today.

Never get lost again

The farm of the future will be "plugged into the planet," both literally and figuratively. Working with GPS and remote sensors, will provide the data to and from the soil to the our data processing center. This same equipment will guide prescriptions aimed at optimizing production from individual field sites. This information conduit will also reach the farm supplier and the farm customer. As the agricultural industry grows this technology each step will dramatically change what we know about what we grow and where it was grown.

Information cycle

Site-specific and information technologies being applied in agriculture today involve the process of turning data into decisions. The data-to-decision process involves four factors:

1. Acquisition of raw data
2. Analysis of information (derived and interpreted data)
3. Addition of knowledge (interpreted and applied data/information)
4. Application of wisdom (desirable end-use of data)

In a typical farm in the upper mid west, this cycle represents one year. It is utmost important a farm operation collects and interprets this data as soon as possible. This typical farm would have some where between 20 and 30 cycles, which may not be enough time to truly understand the variations without the commingling of information with other farmers. Never-the-less harnessing the power of a computer to acquire, analyze and apply information will empower you to understand past performance, as you project and implement strategies to meet economic and environmental objectives for the future of our farm business.

Economic models of the results of computer farming are hard to come by. In part, that's because results are site-specific-and one site will undoubtedly vary from another, depending on history and management.

Most farmers and researchers involved with site-specific technology realize they're collecting data that will be more useful in the future. Aside from record keeping benefits, they expect better models to understand the data and make decisions. Plus, it will take several years to collect data under different weather conditions. (Of course, by then we will be growing different varieties.)

How precise is to precise?

As we start using precision farming, we are concerned with precision accuracy. GPS is measured in meters (approximately 3.2 feet), accepted accuracy is 1 to 3 meters (unless you want to use parallel swathing, where the accepted accuracy is 1 centimeter or less).
The reason GPS technology need not be more precise is the equipment we use to collect and apply the variability.
* In the case of yield monitors, the width of a combine header today is some where between 18' to 45', and speeds from 2.5 to 6.5 miles per hour, and data collection is every one to three seconds. (On our farm, the small grain yield collection area is approximately 28' by 17.6'.)
* Accepted grid soil sample areas are from 2.5 to 5 acres. Dr. Larry Smith, Northwest Experiment Station of Minnesota, has shown that the variability of soil nutrients within a 3 acre grid looks remarkably similar to the variability in an entire field. Such extreme variability presents significant challenges-not only for precise application devices but also for prescription decision making.
* Application equipment we use could be form 1" to 100' wide. In the case of custom application equipment spreading variable rate fertilizer, depending on speed and boom width, an average precise area could be a 44' by 80' area.

The "precise" in precision farming is not as accurate as we thought. But many site-specific precision farming practitioners follow this information-management model:
1. identify practical variability
2. investigate probable causes
3. instigate possible solutions

Since crop production is complex with numerous variables-and often discover significant variability we should understand "practical variability". Practical variability refers to the level of change which can/should be addressed by our current technology, and will be different for every farm.

Precise device, but no advice?

A prescription assumes consideration of the following;
1. The symptoms are diagnosed by an expert
2. There is a determination of the cause
3. A recommendation of a treatment having known effects
4. And the results are dispensed by a licensed technician.

With today's knowledge, writing precise site-specific prescriptions for sub-field areas presupposed more knowledge and wisdom than most farmers and researchers have. The total understanding of spatial variability and interactions need to be addressed and this understanding, economic or environmental models and be built and used.

Many early adopters of this new farming technology realize that site-specific management needs new and improved models for;
1. spatial variability
2. seed selection
3. fertility recommendations
4. weed control
5. in-season management practices
6. and pre-season strategic management planning

Thus will be the new challenge for crop consultants, industry, and research universities.

Using Our Gray Cells

Will industry design systems that allow farmer intervention, or allow a farmer to make these determinations apart from the "magic black box" (computer)? With all this technology helping us to remain in control? Will industry, or will farmers demand, systems that make us so dependent on high-tech devices that we won't be able to farm without them?

So far, we tend to practice a healthy skepticism, except the sugar beet industry in the Red River Valley of the North. The beet industry is in an excellent position to use the basic technology, with the use of grid soil sampling. The nature of how the grower is paid, and the relationship between nitrate fertilizers and quality, makes this an attractive alternative. The only problem is this;
1. Out of thousands of fields grid soil sampled and variable rate applied, (over 125,000 acres in 1996), several fields have been documented to return a positive result. The results have been noted in the $50 - $75 per acre net return per acre. This may be a substantial return but is it statistically significant?
2. It has been reported, in the fall of 1995, several farmers experienced "sticker shock," with variable rate fertilizer application. These select group of farmers did not understand the consequences of the computer generated application maps. Not knowing the amounts and cost found at the completion of application their total per acre cost of fertilizer was between $52.00 and $63.00 compared to a $15 - $21 normal cost, this will be hard to recover the cost over the next several years.

But what do you do when you're confronted with a computer-generated map of your field, and the "computer says" you should apply x amount of fertilizer in this spot? How can you argue-if you don't know the logic it (it's programmer) used?

Current software does not include a provision for the user to identify the origin and status of the data used to generate the map, let alone the logic. But like a spreadsheet, we should be able to look behind the figure and see the equations used to make the map.

Remote Sensing

The first privately owned hyper-spectral remote imaging satellite is scheduled for launch in 1997. Because of imaging resolution and timeliness, the data coming from this first satellite will have limited use in ag production decision making but will have unlimited use in production monitoring.

Data from hyper-spectral images (say one with 200+ narrow band channels) is quite impressive. The data produced will allow an individual or organization to learn more about our farming operation than we will ever know. For example, a company could analyze the data to determine what crops are planted, how "productivity" changes during the growing season, what production practices we use, what conservation practices we follow, etc. And all of this on 100' grids. Realistically, there will be more data available than could ever be generated by an individual producer with perfect records and an on-site laboratory.

The data from hyper-spectral images is so comprehensive that one can determine how much residue we left on the soil surface at harvest. This data offers enormous opportunity for misuse.

We shouldn't expect any help from the agribusiness community. The large ag commodity marketing companies will recognize (if they haven't already) that hyper-spectral data will give them almost perfect crop production information in near real-time. It also sets the stage for rapid vertical integration of grain production, especially by groups that can buy exclusive access.

In a recent memo to the Farm Bureau advisory committee stated; "Think that remote imagining's impact is far fetched? In Australia, they are already routinely monitoring range land by satellite on a weekly basis and telling producers when they must reduce herd densities (and to what level) or move the cattle off completely to minimize environmental damage"

Top 12 yield factors

Within precision farming circles, much attention has been placed on fertility as though it plays the most important role. But if you regularly polled several leading universities and industry specialists, they list fertility much lower in priority. According to Mark Flock, Ag Division Director, Bookside Laboratories, Knoxville. OH, has generated a list from "most important" to least important.
1. Drainage (soil moisture & stresses)
2. Crop Variety (disease resistance, root systems, ability to adapt to extreme conditions)
3. Insect/weed problems (nematodes, etc.)
4. Crop rotation (synergistic effect)
5. Tillage (type, timing, wet/dry soil)
6. Compaction
7. pH (liming) (extreme pH variability (<5.5, >7.3))
8. Herbicides (misapplication and drift)
9. Subsoil condition (acid or alkaline subsoil, clay layer, etc.)
10. Fertility placement (ridge-till, no-till, etc.)
11. Fertility
12. Plant population (most fields have a narrow optimum population)

Mark Flock also stated, "This is dynamic, not a static listing."

It is also stated the importance of keeping records - particularly weather records. The "big event" at critical time periods can really mess up herbicide performance, or cause crusting, or interrupt pollination. Weather at critical times will make or break yield - and you need that information when you interpret your yield maps.

Fertility and precision farming

Many farmers believe variable rate fertilization is the key to precision farming. In sugar beet production, variable rate Nitrogen fertilizer may help the quality of the crop. In other crops this may be not true. In a recent article in the "Top Producer", Don Larson was quoted as "Precision farming began as a method to vary application rates of fertilizer." Over several years of this thinking, Larson hasn't fond much return in that. "Our yield maps are showing that agronomically, fertility is simply not the major issue," he says. "We routinely get our highest yields on some of our lowest-fertility areas. We think that water-holding capacity, organic-matter content, pH levels and other soil characteristics are having a greater impact than nutrient level. This makes it difficult to understand why people are spending money on intensive grid soil-sampling programs."

The ultimate challenge will come when we hire agronomists to help explain the differences that are clearly shown on the maps we are suddenly capable of producing. The majority of crop consultants I have talked to with GPS experience generally agree that most yield variations have very little (if anything) to do with fertility.
Assuming that yield variability relates first to fertility can lead to frustration. Farmers with different soils can see tremendous yield drops, and yet fertility levels can remain the same. Under dry conditions, some varieties with small root systems won't take up fertility very efficiently. But fertility can jump up on the list of other concerns don't overshadow it.

My biggest problem is this, for most crops, majority of information currently being printed is based on grid soil sampling and fertility placement. Common sense dictates that much more can be accomplished by systematically analyzing geo-referenced yield data than an arbitrary grid sampling could possibly do.

I think someone should make it clear to prospective users of a GPS system that fertility refinement is an important but tiny piece of the true value of their investment. Until the cost of this equipment comes down, taking the "GPS plunge" strictly as a sampling and fertility placement tool, probably is not a wise investment.

Yield Monitors

A yield monitor is a great tool for collecting data and showing you what actually took place in a field. The interpretation of the data is what will lead you to change management practices.

The practice of "precision mapping" today, is not necessarily precision farming. "We can collect data form a point in time and space, but we have to relate it back to an overall outcome or management for that field. Tools like GPS can be very useful for finding spots in the field for

future reference or for record keeping. But we need to keep in mind the limitations of the tools and of our interpretation of the data.
Yield monitors can be like truth serum, and some crop consultants would prefer that farmers wouldn't pay much attention to them. They'd rather impress the farmer with precision mapping products. And some crop consultants seem to want to make recommendations and decisions for the farmer. Consultants can sell some farmers on this, but the bottom line is it's hard to make testimonials out of things that are not working.
Improving the management of the controllable factors affecting crop yields is the primary benefit of on-the-go yield monitoring. Accurately knowing the yield variability within a field can become the cornerstone of a crop management plan. But first, it's important to know if the yield variability within the field is stable from year to year. We should find out if some areas consistently yield higher from year to year while other areas consistently yield lower. Else we should find if the yield variability pattern change within the field each year? If the yield pattern is not consistent it's important to determine the cause of this yield instability.

Perhaps weather is the cause. It's wise to have several years of yield data before putting too much stock in the yield maps or before making costly management changes. If the purpose of monitoring yield variability is to compare varieties herbicide rates or types, starter fertilizer, or crop injury from a pesticide, one year of data may be helpful as a starting point, however data from several years will be much more helpful.

If the purpose of monitoring is to improve overall management of the field and perhaps modify some of the soil factors, then it seems wise to have 3 to 6 years of data as a starting point. This is the minimum needed to separate out climate-induced variability within a field.
It is also necessary to look at why yields are variable, considering controllable and uncontrollable factors. Controllable factors are soil fertility, pests, plant population, variety selection, drainage, and tillage.

The goal is to increase profit by improving management of controllable factors, or inputs. But there is an up-front cost for yield monitors, so each farmer must understand and use them wisely to make them pay. Yield monitors can be a cost-effective management tool or a costly gadgets.

On-the-go yield monitors generate a lot of hype and enthusiasm among farmers. Data from the monitors are often expressed in color-coded yield maps for whole fields or farms. But such maps aren't automatically beneficial to farmers. There's much more to collecting, understanding, and managing collected yield data than developing colorful maps.

For the data to be reliable, you need to know that the yield monitor is properly calibrated. Indications are that factors such as constant travel speed of the combine and slope of the field influence the accuracy of the data. In summary, purchase a trustworthy monitor, properly calibrate it before putting too much emphasis on a yield map.
The time spent accumulating yield maps can be devoted to setting goals and laying out a plan for taking advantage of what the technology can offer.

Finally, a yield monitor owner can learn from just watching it operate-without GPS or mapping capabilities. Maps, though, provide more tangible data.

For those farmers who hire crop consultants, using a yield monitor may be a benefit. We as farmers will be able to precisely measure the value of their recommendations.

Ecology first?

According to Joseph Berry, a leading GIS consultant based in Ft. Collins, Colorado, states "If agriculture follows other industries, notably forestry, we'll be using site-specific technologies primarily for environmental litigation anyway-not economy or agronomy."

Why should a farmer get into precision farming?

There are dozens of reasons to seriously consider site-specific farming.
* To determine a way to manage varying soil types within a field
* To decide how to approach drainage problems and if it pays to fix them
* To use Site Specific Farming to better manage inputs
* To identify trouble spots linked to insects or disease
* To generate better farm-specific data for selecting varieties for soil types.
* To impress present landlords or lure new ones.
* To satisfy farm lenders who require yield maps.
* To reduce inputs, or at least apply inputs (chemicals and fertilizers) in a environmentally appropriate manner.

Who's in control?

When we are in our fields and apply any amount of pesticides or fertilizers we assume responsibility for the consequences. We have the liability for the economic and ecological consequences of our decision. The "prescription" will likely be developed by a combination of computer models and local agronomic expertise. Certainly it should also account for the intrinsic knowledge and wisdom of us, the farmer operator. Otherwise, how will we defend ourselves with an environmentalist who questions our farming practices? Their maps and models may use the same data as we do, but may look entirely different because of different assumptions. If the environmentalist doesn't like what was done in a field application, WE not the "intelligent implement" will bear the final liability.

Will we rely on a computer? Or on input decisions made by someone or something else? Remember, it's our data, our dollars, our decision, and our destiny.

Summary

In the long run, we will figure out how to make site-specific farming economical-because we will be using it to meet consumer demand for attribute-specific farm products. Information will be the new farm commodity. Information-rich farmland and farm products may be worth more, too.

Our data is our destiny, past points to the future, and how we collect the data will be our savior. It is important to note that just about every industry that services the agriculture production sector agrees that the farmer should "own the data." The problem is it's not who owns the data, but who controls it. "He who holds information wields power!"

Finally, the data we collect should include;
1. security-(what data gets into what hands)
2. exportability-(not locked into proprietary systems)
3. accessibility-(by the farmer, not just the experts)
4. interpretability-(data pools and common model sets)
5. applicability-(integration with other data and decision support models)
6. understandability-(where the numbers come from, how parameters are weighted)

Data Sources,
Entrapped or Empowered by Technology? Grant D. Mangold, Editor ag/INNOVATOR
Does precision pay its way? Charlene Finck, Farm Journal, 1/1996
Soil Specific Crop Management University of Minnesota conference 1992