Site-Specific Management Guidelines

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Profitability of Site-Specific Farming

Summary

When is site-specific farming (SSF) profitable? What makes it profitable or not? This *Guideline* looks at both variable rate (VR) input applications and yield mapping. It demonstrates basic budgeting methods to measure average profitability. Profitability results from nine field research studies show that high-value crops give the biggest payoff to VR fertilizer application. Many yield map benefits come from whole-field improvements such as drainage, land leveling, windbreaks, and fencing. Farmers and agribusinesses should remember that because SSF practices are site-specific, their profitability potential also will be site-specific.

Introduction

Applications of SSF technologies can be grouped into two categories depending on whether they focus on inputs or outputs.

- **Input focus**
- **Examples**: VR application of fertilizer; site-specific choice of herbicides or seed varieties.
- **Purpose**: To make more efficient use of conventional inputs.
- **Output focus**
- **Examples**: Maps of crop yield, moisture, and quality.
- **Purpose**: To identify problem areas for later management, either using VR inputs or other methods.

The commercial focus on VR input application has made it the object of most economic research on SSF. Among SSF technologies, cost and benefit data are most readily available for VR technology. Yield mapping fits easily into existing production systems, but it has been the subject of few economic studies. This is mainly because yield map benefits are difficult to capture in on-farm trials. This guideline focuses on two topics:

- When has VR input control been profitable, and why?
- When and how can yield mapping and other output monitoring add to farm profits?

Partial budgets to calculate profitability of variable rate applications

Partial budgeting has been the most common tool applied to analyze the profitability of SSF. A partial budget focuses on only those cost and revenue items that *change* when using new practices. It subtracts losses (increased costs plus reduced revenues) from gains (reduced costs plus increased revenues) to estimate the change in net revenue that results from adopting a new practice such as VR input control. Partial budgets are usually calculated on a per acre or per field basis. A more complete profitability analysis would include whole farm impacts as well as risk effects, but the partial budget is an excellent way to start looking at average profitability.

a. Include all costs that vary

Estimating the cash costs that vary is the easiest part of a partial budgeting analysis of SSF. Cash costs have either been paid or can be estimated based on commercial charges. The key is to remember to seek out *all* costs, including those like training that are not charged on a per acre basis, and to allocate them over the appropriate time period and acreage. Careful cost accounting is key: Many SSF profitability analyses seriously underestimate information costs – some ignore them altogether. This is just as true for university studies as for media and industry reports.

b. Adjust long-term costs to a one-year basis

In particular, remember that SSF information is often useful for more than one year. So its cost should be allocated over its entire useful life, just as for any depreciable asset. Information related costs include: grid soil sampling, laboratory analysis, purchasing digitized soil maps, software, yield map making, and training needed to interpret soil test or yield maps. Information costs that are not charged on a per acre basis (e.g. soil maps, software, training) are often allocated evenly to each acre on which

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that information is used. An example of allocating the cost of phosphorus (P) and potassium (K) soil test information over a useful lifetime of four years is given in **Table 1**. The example uses an annuity formula to estimate annual costs based on straight-line depreciation and a 10 percent cost of capital (discount rate).

Table 1. Annualizing information costs: the example of P and K grid soil tests for a 40-acre field with a 4-year soil sampling cycle.

Item	Unit	Quantity	Price	Amount
Soil test labor*	Hour	3.25	$10.00	$32.50
Soil test lab analysis	Test	13	$7.50	$97.50
Total variable cost				$130.00
Annualization factor at a 0% discount rate				x 0.32
Annualized cost for 40-acre field	Field	1		$41.01
Annualized cost per acre	Acre	1		$1.03

* Assumes an approximately 3-acre grid and that 15 minutes are needed to collect and package each sample. Source: Swinton and Lowenberg-DeBoer, 1998.

c. Add revenues that vary: A partial budget example with variable rate NPK

On the revenue side, information increases profitability only if it changes decisions. Yield gains are the principal in-field source of revenue increases anticipated from SSF. The partial budgeting example in **Table 2** is drawn from on-farm trials of site-specific management by soil type in central Illinois (Finck, 1998). These trials integrated variable rate management of fertilizer and planting rate on a 1,300 acre farm producing a 50/50 corn soybean rotation. On this farm the major benefit of site specific management was an increased corn yield on the lower yielding soils. The average benefit over three years and all soil types was about 15 bu/A. Overall fertilizer costs decreased slightly ($3.87/A), but not enough to cover the increased cost of soil sampling ($5/A) and variable rate application ($5/A). Applications of nitrogen (N), P, and K decreased, while micronutrient applications increased slightly.

Equipment costs were estimated using a net present value-based sinking fund approach with a 10 percent cost of capital and a 3 year useful life. The short useful life was used because with rapid technological change the useful life of site-specific management equipment is probably similar to that of computers and other electronic equipment. The yield monitor and global positioning system (GPS) costs were spread over all farm acres because they were used for both corn and soybeans. The planter and anhydrous ammonia controller was used only for corn, so that cost is allocated only over the 650 corn acres. Overall seed costs did not change much because increased seeding rate on high yield soils almost balanced reduced seeding rate on lower productivity soils. The consulting fee of $650 is spread over all 1,300 farm acres. It reflects the cost of the increased knowledge component of site specific management. Knowledge costs are incurred whether the farmer buys consulting services or develops the necessary skills on the farm.

Table 2. Partial budget example for site-specific management of corn in central Illinois.

Item	Unit	Quantity	Price	Amount
Change in yield	bu/A	15.32	$2.30	$35.24
Change in equipment cost per acre (10% discount rate; 3 year depreciation)				
Yield monitor	Item	1	$4000.00	$1.33
GPS	Item	1	$6000.00	$1.99
Planter & anhydrous ammonia controllers	Item	1	$5000.00	$3.32
Microcomputer & printer	Item	1	$3000.00	$1.99
Total increase in equipment cost				$8.62
Change in fertilizer cost				
Nitrogen	lb/A	-0.044	$0.25	-$0.11
Phosphorus	lb/A	-14.66	$0.30	-$4.40
Potassium	lb/A	-3.33	$0.13	-$0.43
Sulfur	lb/A	2.17	$0.21	$0.46
Zinc	lb/A	0.11	$2.36	$0.26
Boron	lb/A	0.05	$7.17	$0.36
Total change in fertilizer cost				-$3.87
Change in seed cost	Bags/A	0.01	$90.00	$0.48
Change in soil sampling cost	Acre	1	$5.00	$5.00
Change in fertilizer application cost	Acre	1	$5.00	$5.00
Consulting charge	Acre	1	$.50	$0.50
Net return to site-specific management	Acre	1		$19.50

Source: Finck, 1998. NB: Numbers do not sum perfectly due to rounding.

d. When is variable rate profitable? Evidence from published studies

The published results on profitability of VR nutrient applications can be difficult to interpret, because authors use different experimental designs and different assumptions about which costs to include. In a recent article, Swinton and Lowenberg-DeBoer (1998) examined profitability results from nine university field research studies of VR fertilizer applications. They applied standard minimum cost assumptions to all studies where selected cost items had been omitted. They found that the value of crop yield gains was especially important. High value crops that responded to VR fertilization tended to do so more profitably than low-value crops, because the yield gains were worth more. Variable rate fertilization of wheat and barley was nowhere profitable, the results for corn were mixed, and VR fertilization of sugarbeet was profitable. By contrast, cost savings from reduced fertilizer application were much less important. The fertilizer inputs being managed are fairly low cost, and only one study managed more than two of them. Given that soil testing is fairly costly, most of the crops are of fairly low value, and macronutrient fertilizers are relatively cheap, the cost of overfertilizing is fairly low.

Most SSF profitability studies have compared average returns between treatments with and without VR fertilizer application. These results are based on the average net returns across all replications of each treatment. In theory, SSF could also reduce the *variability* of income within a year. A recent study of VR P and K management of Indiana corn suggests that management by soil type would be the strategy preferred by risk averse decision makers. This was true even though average net returns were about the same for fertilizer management on the basis of both whole field and soil type (Lowenberg-DeBoer and Aghib, 1999).

Profitability of yield mapping

Measuring the profitability of yield mapping (and other ways of monitoring outputs) is more difficult than variable rate inputs. A yield map displays information, so its value depends on what one does with that information. Doing something with that information to increase profits will require added work and inputs. For example, suppose a yield map highlights a drainage problem. A closer look shows that tile lines were clogged over an area of 12 acres. Two days work and $800 unclogs the tile lines. When corn yields there rise by 10 bu/A the next year, is the yield gain due to a) the map that helped diagnose the problem, or b) the two days work and $800 that fixed the problem?

The major benefit in this example seems to come from diagnosing the problem and deciding to fix the tile line. So the profitability of the yield map is the value of added yield after paying the cost to fix the tiles. If the work was worth $200 per day, then it took $1200 to fix the clogged tile. With corn at $2/bu (net of harvest costs), revenue goes up by $240 in the first year. But yields should go up in future years too, making this a standard investment returns problem. So how many years should be counted? And is a yield gain in 10 years worth as much as it is today?

a. Net present value

Calculating net present value (NPV) gives the most reliable measure of profitability from an investment, such as yield mapping. The ingredients needed are:

1) a list of costs and revenues each year due to the investment,
2) the maximum number of years the investment is relevant, and
3) the rate of return that could be earned on money if it hadn't been put it into this investment (the "discount rate").

Table 3 shows how the example above could pay off over 10 years with a discount rate of 10 percent if yield gains remained at $240 each year (as in a corn-soybean rotation where bean yields gain an average of 4 bu/A at a net harvest price of $5/bu).

Table 3. Net present value of yield map benefits from improved drainage in a single field.

Year	Item	Current value	Present value of $1 @ 10% discount	Present value	Accumulated present value
0	Fix tile	-$1200	$1.00	-$1,200	-$1,200
1	Yield gain	$240	$0.91	$218	-$982
2	Yield gain	$240	$0.83	$198	-$783
3	Yield gain	$240	$0.75	$180	-$603
4	Yield gain	$240	$0.68	$164	-$439
5	Yield gain	$240	$0.62	$149	-$290
6	Yield gain	$240	$0.56	$135	-$155
7	Yield gain	$240	$0.51	$123	-$32
8	Yield gain	$240	$0.47	$112	$80
9	Yield gain	$240	$0.42	$102	$182
10	Yield gain	$240	$0.39	$93	$275

The accumulated net present value at the end of 10 years is $275 in today's dollars. That means the farmer would earn $275 more from this investment than from others that paid 10 percent. If that were all that was earned by the investment in yield mapping, it wouldn't come close to paying the cost of a yield monitor. But the value of the yield monitor and mapping investment comes not just from this field in this year, but from every field in every year that decisions are made based on the yield map information. So, the profitability of yield mapping is the sum of all net present benefits from the decisions it triggered, minus the cost of the yield monitor, map making, and related costs.

b. No hard evidence of yield map profitability yet

Because this kind of measure has to be made over time, there are no comprehensive studies yet that show how much yield mapping contributes to the bottom line. But sales of yield monitors have been jumping by 70 to 300 percent annually for the past five years. And yield maps are the only practical means to measure the value of field level improvements such as drainage, land leveling, windbreaks, and fencing. Interviews with Michigan farmers suggest that yield map information applied to whole-field investments may be far more valuable than adjusting variable inputs (Swinton et al., 1996). Apart from field improvements, yield maps may also contribute to profits via data sales to interested agribusinesses, by making on-farm experimentation cheaper (saving weigh-wagon time) and by improving bargaining power in land rental negotiations.

Practical implications for farmers and agribusinesses

The most durable investment that farmers and agribusiness can make in SSF is to develop the *capacity* for site-specific management. Agriculture is becoming a knowledge based industry where the ability to learn efficiently is a key factor in profitability. Site-specific farming technologies are sure to change. As with most computer technology, any SSF equipment and software bought today will probably be obsolete in 3 or 4 years. In this environment of rapid technological change, the most prudent farm and agribusiness strategy for most field crop producers is to learn about SSF and to develop a historic, spatial data base.

Building a good historic, spatial information base is easier said than done. The costs of information collection (e.g., soil sampling and analysis) and management (VR controllers and application) are substantial. But custom combine operators who offer yield mapping can help build that data base without equipment investments. Wholesale adoption of SSF should only be attempted by those in strong financial condition who can absorb significant losses while learning. Farmers in weaker financial condition should apply the best whole field practices until more is known about SSF technology and its long term benefits. For farmers who do not do whole field soil testing regularly, that is a good place to start.

Future research needs

Data collection and information management are the twin functions whose costs drive the economics of SSF. Making SSF more profitable for farmers in the future means 1) making data collection cheaper and better, and 2) making better recommendations from available data. Although sensor technologies have evolved dramatically over the past few years, continuing breakthroughs are the key to cheaper, better data collection.

Developing improved, site-specific recommendations algorithms is a much greater challenge. Current university fertilizer rate recommendations are very rough. Most are based on yield goals for specified soil map units, ignoring variability within a map unit and assuming average weather. The challenge to agronomic researchers, both public and private, is to develop new quantitative methods to allow growers and consultants to develop and improve their own site-specific recommendations for crop input management. ■

Critical references and additional reading

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