Site-Specific Management Guidelines

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Strategic Approach to Site-Specific Systems

Summary

Site-specific management must be approached logically and systematically. Like any major change, it is easier to break the process into manageable action steps that ultimately build to a complete management system. A strategy is offered in contrast to a generalized recipe of tools and practices. A successful strategy considers farmer goals and characteristics of the individual farm, farmer, and fields before decisions about tools and practices are made. A strategic approach for site-specific management might include the following.

Define goals. • List the decisions that must be made to reach the goals. • Determine the data needed to support the decisions. • Determine the tools needed to collect/manage/interpret the data. • Determine requirements for implementation. • Inventory the human, physical, and information resources available. • Make adjustments to meet projected future needs. • Collect and interpret the data needed. • Modify the production plan based on the interpretation of the data collected. • Implement the improved plan. • Repeat the process.

Designing a Strategy

Designing a successful site-specific management strategy is challenging because factors affect crop yield and quality at specific sites within fields. A paper by Beaufils published in 1973 eloquently addresses this concept with a focus on plant nutrition. **Figure 1** is a modified version of one of his illustrations. The factors on the far left are uncontrollable while those on the right are cultural practices which are controllable. All of these factors influence plant metabolism, which impacts plant composition, which in turn influences crop yield and quality. The system is complicated further because cultural practices can modify the impact of the uncontrollable factors such as light, temperature, moisture, and soil properties. It is not surprising that precise nutrient needs for each field area are difficult to predict.

Crop simulation models will become more common as management decision aids. Used primarily as research tools in the past, models provide a framework upon which to design management systems. They help organize management decisions and data available to support those decisions. Only recently has the computer power and the level of data detail needed for using models become practical for farm application. The next step will be combination of models, data storage, and the knowledge of farmers and their advisers into expert systems and neural networks. These exciting new tools are beyond the scope of this paper, but are well worth watching for future needs.

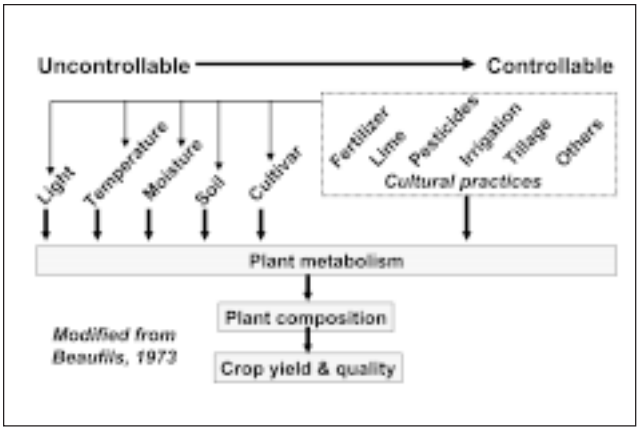

Figure 1. Factors affecting plant nutrition at a given site.

Define Goals

Implementation of site-specific systems for crop and soil management should be approached in a systematic manner. The first step is to define the goals for the operation, considering the resources available and the interests and skills of the management team. Goals should include production, economic, and environmental considerations where applicable. The goals should be site-specific, realistically geared to the individual farm and farmer.

Farmers want to increase profitability; however, it is clearly not the only goal. Other goals include avoiding negative environmental effects, being in regulatory

compliance, verification of compliance, as well as yield levels and management practices, more time for family and recreation, and enriching the resource and information legacy that is passed on to the next generation.

Yield is the first goal that comes to mind in improving profitability. Marketing strategies are important, too, but regardless of the price, profits will be greater as yields increase. The farmer has much more control over the factors affecting yield than over the factors affecting market price. This will shift as price received becomes more dependent on quality of the crop. Yield is still the driving force, but it may be yield of a quality component, such as protein or isoflavones, rather that total crop yield.

The potential for increasing yield is great because of the small portion of the crop's genetic potential that is typically realized. A 370 bu/A (23.3 t/ha) yield record for corn was measured in 1985 on the central Illinois farm of Herman Warsaw. When the genetic and technological advances that have taken place since then are considered, one cannot help but become optimistic about increasing yield. In 1997 and 1998, an Iowa farmer, Francis Childs, won the U.S. National Corn Growers Association Yield Contest with consecutive yields of 345 bu/A (21.7 t/ha). Both farmers produced these yields by implementing systematic, detailed management plans on their fields. They weren't using satellites and computers, but rather focused on details of the factors influencing yield. Their approach was still *site-specific* management.

Crop production historically has been in the commodity mode, providing a raw material of grain and fiber, for the feed industry, and other uses. This system rewards quantity and pays little dividend to quality. That is changing. New market trends focus on quality components and on the needs, desires and demands of the *customer*…whether it be a hog feeder in the next county or a food processor on the other side of the world. These customers face increasing demands from their customers, and passing those requirements on to their raw material suppliers. Grain and fiber producers who recognize these requirements and respond favorably may be rewarded in the marketplace. Many of these requirements will force site-specific management to be a part of the normal production system.

What decisions must be made to reach these goals?

A series of decisions must be made in the process of working toward the established goals. These include selection of crops to be grown and the rotation plan, tillage system to be used, nutrient management planning, genotype selection, planting system, pest management, scouting activities, harvest, handling, and marketing. These decisions are often interdependent and also dependent on outside influences. Yield goals, goals for soil and water conservation, goals for improving productivity…all should be considered.

What data are needed?

To support the management decisions, various kinds of data will need to be available. Records of previous crops, soil characteristics, soil nutrient levels, anticipated pest and weather stresses, potential markets, and other information help guide decisions. Until such information is available, decisions may be limited.

What tools are needed to collect/manage/interpret these data?

"Site-specific management" often immediately brings to mind new technology such as global positioning satellites (GPS), geographic information systems (GIS), variable-rate controllers, computers, and various other electronic "gadgets" that measure and control different components of the management system. But it is important to recognize that most of what is done in site-specific management doesn't ***require*** computers and satellites. They just make the process easier to handle.

Begin with a good computer system with plenty of RAM and data storage. While computers are not essential to site-specific systems, they are the only practical solution to handling the large amounts of data that are generated. Be sure you have…and **use**…a good backup system, storing backup data sets in a totally separate location. The data set soon becomes the most valuable part of the site-specific system and you can't afford to take chances. Computer failures, theft, fire, tornadoes, and floods can destroy years of records in an instant.

Invest in a good GPS system that is reliable and has the proper differential correction for your area. Local dealers and experienced farmers or consultants can advise you on the selection. Learn to use a GIS system. If you don't want to do the data management yourself, work with a local service provider, but learn enough so that you gain an understanding of how that resource can help you with management decisions.

What is required for implementation of the system?

Site-specific management is a commitment….to pay attention to and work with the details of crop and soil systems. If you are not willing to spend the extra time and effort to build the data sets and interpret the results, you should not consider site-specific management.

Site-specific systems feed on data. Until you collect a minimum level of base data, you can't make site-specific decisions. The kind of data will depend on the decisions to be made, but some basic components will be needed for most systems:

- Yield data • Soil characteristics • Weather • Production practices • Scouting records • Soil test and nutrient application records • Economic records • Aerial images

Several years of data may be needed before you can make a decision with confidence.

Take Inventory

What is known?

What have been the previous yields for different crops and different kinds of growing seasons? Are there any particular recurring stresses such as drought, drainage problems...any special pest problems? How variable are the whole-field soil test values over time? Are there areas where manure was differentially applied or did the field contain a feedlot? This kind of information is needed to make adjustments in the management plan. Get a copy of the latest soil survey for the farm. If there is not a good survey available, consider hiring a soil scientist to work

with you in evaluation of the soil resource. Accurate soil characterization information can improve many management decisions. For high value crops or areas with large soil variation, an Order 1 Soil Survey can provide valuable information.

What must be measured?

Document all inputs, including timing, rates, and formulations. With the use of biotechnology and genetic/pesticide combinations, records of the genotypes planted and pesticides used are critical…and may need to cover several seasons.

Soil testing is still one of the most important field measurements. Soil survey information gives some general guidelines, but for most cropped fields, man's activities have as much or more influence on variation in nutrient supplying power to the crop. With site-specific management, soil testing takes on some new dimensions…understanding the spatial variability within the field becomes an important information resource.

Scouting fields cannot be over-emphasized. Mapping locations of observed problems…poor stands, pests, nutrient deficiencies, etc.…will help interpret yields and other end-of-season observations. Use GPS to geo-reference observations. Take notes, take pictures, take samples…whatever is appropriate to document the observations.

Remote sensing can be a useful data gathering tool, being capable of covering large areas in a short time. Generally best used in conjunction with a good ground-reference data collection system, remote sensing is being evaluated for its ability to aid in management decisions.

What resources are available?

Part of the inventory process is to determine what resources are available with which to implement a management system. The resources may put limits on the system, at least in the short-term, and defining the available resources is the first step toward overcoming these limitations in the long-term.

Human Each farm has a different set of human resources on which to build a management team. The farmer…and the farmer's personal education, experience, and motivations…is the main resource. But every farmer is surrounded with a team of advisers, input suppliers, hired labor, and family members that all bring unique talents and interests into the operation. It might be best to formalize the team, with each member's expected input into the decision and implementation process clearly defined. That will make it easier to identify voids where additional support may be needed.

Equipment Too often we put the equipment first in the management process, letting it dictate too much of the decision-making. While economics may dictate the ability to make major purchases at one time, an equipment acquisition and replacement plan is important.

Data Records are becoming more important as management intensifies and crop production becomes complex. Processors and consumers are demanding more accurate accounting of inputs used. Consultants need records to help with decisions. Records are needed to document what happened and when, not only as a management tool, but also to help identify problems that occur in the course of the season. Each season the data set is expanded, and its value increases. A well-documented record set is a major resource for the farm. It can also be a selling tool for a farmer seeking to rent additional land, or to borrow capital for improvements on the farm. Scouting records, soil test data, weather data, and yield data are among the minimum data set that should be kept.

Unmet resource needs—where/how to get them?

It is rare for all of the human, equipment, and data resources needed to be available on the farm. Most farmers depend on outside input to supplement their own resources. Contracting with consultants for the areas of expertise the farmer personally doesn't have is a common practice. Sometimes the size of the operation dictates that there must be outside consultants to help cover all of the decisions. Specific equipment needed may be too costly for the farmer to own outright, so leasing or sharing becomes a more viable option.

Take Action

Plans have little value until they are implemented. The plan should have definite action steps clearly defined and linked to a timeline for action.

Collect the data needed

Since data drive site-specific management, data collection is a critical component. Plan ahead. Be sure the data collection system is ready to go BEFORE you go to the field. Check wiring and connectors, backup batteries and power supplies. Fix or replace any components that show evidence of failure. The cost of repairs is minimal compared to the value of missing the collection of a key data set. If possible, do advance calibration and data checking to be sure everything is working as it should.

Collect the data. There may be some tough decision points…such as when a sensor or controller fails…when you have to decide whether to stop and make a repair to the data collection system or sacrifice the data to get the job completed. Evaluate decisions depending on these data and what their loss will mean to the long-term data series and decision process.

Transfer the data to permanent storage…and backups…as soon as possible. That helps prevent accidental loss and gives an opportunity to detect and correct electronic or mechanical problems early. Many farmers perform the data transfer and backup processes each night. Your schedule should be geared to the workload, but delays are often costly.

Interpret data

Data are useless without interpretation. Learn to use software tools that can help summarize and interpret data from soil tests, yield monitors, and other sources. A good GIS package is helpful...so are spreadsheets, or models, or other tools that help sort and analyze and interpret the data collected, putting it into formats that help farmers and their advisers visualize the relationships needed for decisions. Modify the production plan as dictated by the interpretation of the data collected.

Implement the plan

Planning is only part of the process. You have to take the steps to *implement* the plan. Otherwise, all of the investment in data collection and interpretation are wasted. Too often, this is where the process fails. Change is not easy. Managing at the detailed level of site-specific systems takes special commitment. That must be made from the beginning, or site-specific management will not work.

Measure and evaluate the results

During implementation, the process starts to recycle. Additional data are accumulated to build the data base upon which future decisions can be made, but also to document the effects of the changes made in the system for the current season. The yield monitor is the most common tool for measuring results, but again the high-tech tool is not essential. Hand checks and weigh wagons can provide useful information. Most people, however, find that the yield monitor is the first investment to make.

Results other than yield are important. You may be equally interested in scouting reports, soil tests, and other observations. Ultimately, a site-specific system should geographically-reference all of these data and observations and catalog them in a GIS data base. This might include digital photos or digital video of observations as well as hard data. It all becomes part of the package for evaluation.

Repeat the process

Farming is cyclical. Once the season is over, it is time to start the plan for the next season. Many of the decisions for next year's crops must be made…or at least started… well before this year's crop is harvested. Again, a timeline of action steps will help keep the plan on track.

Set Milestones/Checkpoints

Depending on the cropping system and the kind of management practices being implemented on a site-specific basis, you will have a number of checkpoints during or throughout the season that help determine whether the plan is reaching its intended goals. These should be written down and carefully followed. Often mid-season corrections are possible. In any case, these checkpoints provide valuable information for interpreting results and for revising the plan for the next season.

Economic Analysis

Farming is a business. Businesses are fueled by money. Economic analysis is an essential part of site-specific systems.

Is it sustainable…short-term and *long-term?*

The management plan must provide adequate return on investment to keep the business solvent on a year-to-year basis. Some short-term deficits can be tolerated if there are sufficient financial resources, but unless the general tendency is "in the black", there will be no long-term business success. Detailed budgets should be kept during implementation, and economic projections for the future should be part of the evaluation of success.

HELP!!!

Site-specific technologies are the most agronomically demanding crop production tools ever developed. Their successful application depends upon our agronomic understanding of the cropping systems being managed. GIS databases can either empower or entrap. Agronomic knowledge and common sense make the difference. Without the agronomic understanding to properly interpret and verify the relationships among layers, the assumption of cause and effect between layers that may be highly correlated can lead the manager to reductions in efficiency and profitability rather than gains. Most farmers realize that they cannot keep up with all of the developments in technology and data management without assistance. It takes a team of people to handle all of these components. Research and training…and continuing education programs for retraining…must be maintained and directed toward providing these human resources. There has never been a greater need for agronomic research and training nor a greater need for well-trained agronomists to be in the fields observing, recording and recognizing the limitations of the new technology and the old technologies such as soil testing or plant analysis. The most important processor in the whole system is not the one *in* the computer, it's the one *holding* the computer. ■

References

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