

Guidelines for Adopting Precision Agricultural Practices

T.S. Stombaugh, Biosystems and Agricultural Engineering; T.G. Mueller, Agronomy; S.A. Shearer, Biosystems and Agricultural Engineering; C.R. Dillon, Agricultural Economics; and G.T. Henson, McLean County Extension Agent for Agriculture and Natural Resources

Background

Precision agriculture (PA) is the process used to vary management of crop production across a field. It is becoming a popular tool for Kentucky producers. Like many new technologies, it may increase farm income, but any benefits from using PA may be offset by the costs of adoption. The key to success is prudent adoption and use of PA technology. This publication guides producers through a series of steps to help them evaluate the appropriateness of PA practices for their operations.

We have not attempted to individually address the variety of agricultural enterprises in Kentucky. Most PA equipment and software available today is targeted at grain production, so the guidelines outlined here are most directly suited to grain enterprises.

Potential Benefits

PA's effectiveness is highly dependent on how much variability exists within your fields and your ability as a producer to identify and put into use the best management practices for each field's sub-area. If you properly use the spatial data PA can provide, you can realize the following potential benefits:

- **Increased profits through increased efficiency.** With PA, you can use farming inputs more efficiently by applying more of them where more are needed and less where less are needed. For example, you might find it profitable to reduce inputs in one part of the field, which would mean a small sacrifice in yield but ultimately mean you would make more money.
- **Reduced agronomic inputs.** Many producers who adopt PA technologies find their overall use of production inputs (fertilizer, lime, and chemicals) decreases because they can better adjust, to a field's fertility level, the amount of inputs applied. Many fields in Kentucky have high fertility over a large area and low fertility only in small sub-areas. With PA, fertilizer can be applied only to those small sub-areas.
- **Better Record Keeping.** PA technology generates large amounts of data that are spatial records of inputs and outputs for fields. These data can help you create more accurate management plans.
- **Improved production decisions.** PA can be used to make land-use decisions. Profit maps, which show the spatial distribution of a field's profitability, can help you make decisions about which cropping systems work best. You may also be able to identify areas that should be enrolled in government programs such as the federal Conservation Reserve Program (CRP) or removed from production if low yields cannot be profitably corrected.

- **On-farm research.** The ability to quantify the spatial performance of crops will allow you to conduct more comparison trials within fields. For example, it is relatively simple to compare the performance of different varieties on different soil types when you practice PA.
- **Reduced environmental impact.** If you apply and use production inputs more efficiently, less material will leave the field through surface water and groundwater. Reduced environmental impact can only improve the public's perception and acceptance of producers' agricultural practices.
- **Property advantages.** Many landlords are giving preference to farmers who can create yield maps and other files of spatial data for the fields they farm. This spatial history may also increase the value of cropland you own.
- **More ground farmed.** The records generated may allow you to effectively manage more cropland than you have in the past.

Assessing Your Operation

When you adopt and use any new farming practice, you need to consider how it will improve your operation and, more importantly, whether you can adjust to using it. These considerations are especially true for PA, since adopting it will mean a significant capital investment. You want to be sure you don't become a victim of the technology. Assess how prepared you are by answering the following questions:

Do you keep accurate field-based production and financial records? By knowing the amount of income each field generated in the past, you can gauge the impact of improvements that could mean additional income. Field-based record keeping also allows you to consider which fields may be better candidates for spatial management of inputs. If you do not now keep rigorous financial records, you may want to consider enrolling in the Kentucky Farm Business Management Program, which is administered through the UK Department of Agricultural Economics.

Do you use an office or home computer for making management decisions? Computers and the accounting, spreadsheet, and mapping software packages used with them are changing the way farmers conduct business, and the Internet and e-mail are becoming important ways of obtaining product and management information. Both computers and the Internet are also key components of a PA management system.

Do you routinely sample soil on a field-average or regional basis, and do you have a nutrient management program in place? PA is not a substitute for sound, traditional management practices.

Do you use any map-based information, such as soil surveys or topographical maps? You should have a general idea about the variability of your fields before you get started in PA.

Do you routinely obtain crop scouting reports or participate in integrated pest management (IPM) programs? You should periodically scout your crops either on your own or by taking advantage of existing programs offered by Certified Crop Advisors (CCA), service providers, and the Cooperative Extension Service.

Getting Started

If you answered “yes” to all the above questions, it may be time to move to the next level—adoption and use of appropriate PA practices. Clearly identify your goals in the beginning. You, like most producers, likely want to ultimately maximize profits, but you may not have identified a specific way to reach that goal. First ask yourself how you intend to increase income. Will you continue to farm the same land? Do you have fertility problems that need to be corrected? Are there improvements that may be justified, such as the addition of tile drainage?

Once you have identified your goals, perhaps the first and most important decision to make is whether to purchase PA services or to develop PA capabilities within your own operation. It may be more cost effective to purchase some services, such as variable-rate fertilizer application, but absorb the cost of other activities, such as yield monitoring, within the farming operation.

If you intend to purchase PA services, start small by signing up or enrolling smaller portions of your farm for a trial period. Continue to ramp up enrollment as you obtain results that support the adoption of PA practices.

If you intend to develop PA capabilities within your operation, we suggest the following steps:

1. Purchase a mapping program.
2. Collect spatial data.
3. Map field boundaries.
4. Keep records.
5. Obtain remote images.
6. Purchase a yield monitor.
7. Purchase a DGPS receiver.
8. Generate yield maps.
9. Use yield maps for scouting.
10. Generate profit maps.
11. Use yield and profit maps for land-use decisions.
12. Take site-specific soil fertility samples.
13. Manage subfields.
14. Adopt variable-rate technology (VRT).

1. Purchase a mapping program. Your first and most essential acquisition will be an entry-level mapping program, which will allow you to import, overlay, and manage spatial data. This software will enable you to develop a geographically referenced database for your operation. Costs and capabilities of software vary greatly from vendor to vendor, so look at several different

packages and then select software that is consistent with your goals and will allow you to add more capabilities in the future. Consider all costs, including that of any training, annual support, and service contracts you may need.

2. Collect spatial data. Look for existing geographically referenced data on the Internet. Several databases are available free of charge. From the Kentucky Office of Geographic Information Systems, on the Web at <www.state.ky.us/agencies/finance/depts/ogis/ogisfram.htm>, you can obtain:

- digital ortho quarter quads (DOQQ).
- high-resolution aerial photography.
- TIGER line files, which describe roads and boundaries.

You can obtain digitized soils maps for some Kentucky counties from the Natural Resources Conservation Service, which is on the Web at <www.ky.nrcs.usda.gov/soilstatmap.htm>. These and other layers of information will form the basis of your farm’s geographic database.

3. Map field boundaries. Service providers will map your fields for a nominal fee, or you can obtain a digital global positioning system (DGPS) receiver and a laptop or hand-held PC and do it yourself. Boundaries can also be obtained from digital ortho quarter quads, although their use is less accurate. Many producers are surprised to find differences of 7 to 10% in field acreages when they compare the DGPS results with values they have been using for years. Accurate field boundaries, including field features such as waterways and outcroppings, will add spatial precision to your farm’s geographic information systems (GIS) database.

4. Keep records. Farm records should be organized on a field-by-field basis. These records should include:

- historical yields (whole field).
- field boundary locations.
- soil test values.
- management history, including past fertility, tillage, pest management practices, and financial records.

To the extent possible, these records should be archived electronically in your mapping system. In some cases, you may have to add user-generated sketches indicating different features, such as where different varieties were planted or where an old feedlot was located. All information you collect in the future should be added into this system as well.

5. Obtain remote images. Aerial or remotely sensed images of your fields should be obtained one or more times during each growing season. You can use these images to identify management problems that cannot be seen from the ground. For example, you can locate areas where inputs such as nitrogen have been misapplied. It may also be possible to detect moisture or pest stresses. While it may be too late to correct some of these problems during the current growing season, the manager and employees can become mindful of the potential economic impact of these problems so they can be avoided in the future. One way to obtain remotely sensed images is by flying over the fields in a small aircraft and taking pictures with a 35-millimeter or digital camera. Satellite imagery is also becoming economical

and more readily available, but it is sometimes difficult to get timely satellite imagery at the resolution you want.

6. Purchase a yield monitor. A yield monitor on your combine will allow you to determine total yields for fields or areas within fields without a weigh wagon or scales. This yield information will make it possible to do side-by-side comparisons of hybrids or management practices. In addition, the dynamic yield indicator in the combine's cab will enable the combine operator to observe quantitative differences in yield throughout the field.

7. Purchase a DGPS receiver. You can greatly expand what a yield monitor can do if you add a Differential Global Positioning System (DGPS) receiver. The yield monitor will record DGPS position along with yield, enabling you to create yield maps and evaluate how your yields vary according to location. The same DGPS receiver can also be used for field scouting and for controlling variable-rate application equipment. When purchasing a DGPS receiver, pay close attention to the unit's accuracy. In addition, you will need to identify a source of differential corrections for your receiver. There are several differential correction providers. Some are free, such as the U.S. Coast Guard's Beacon and the U.S. Federal Aviation Administration's Wide Area Augmentation System, and some are commercial, such as Omnistar and Racal. Check availability and pricing in your area before purchasing DGPS equipment. It may be possible to purchase a DGPS receiver along with a yield monitor at some savings.

8. Generate yield maps. With your yield monitor in place and a DGPS receiver connected, you are ready to create yield maps. Most yield monitors have companion software that will create yield maps from field data. Your mapping program can also create yield maps. The maps will give you a visual indication of your crop's performance, and the data they provide will allow you to quantify how that performance varies, answering questions such as:

- How much did the yield vary?
- What areas of the field were affected?
- How big were those areas?

9. Use yield maps for scouting. One of the fundamental uses of yield maps is to locate trouble spots in a field. When you discover an area of low yield, try to find an explanation for the decreased productivity. Look at your soils map to see if there might be variations in soil type in that area. Obtain other historical information about the field:

- Was there an old fencerow or feedlot in that area? Go out to the field and look for the problem.
- Was there a weed or pest infestation?
- Was there a drainage or moisture problem?
- What kinds of input treatments have been applied?

The yield map will help you locate problems you may not have been aware of. Once you identify them, you can decide if they can be profitably corrected.

10. Generate profit maps. If you have been keeping good records, including accurate yield maps, you will then be ready

look at the field's profitability. Use yield information along with the cost of all inputs and field treatments, such as tillage, to generate a profitability map of the field. Locate areas of high and low profitability. Continually ask yourself why one part of the field made more money than another part. What could you do differently to make more money?

11. Use yield and profit maps for land-use decisions. A land-use decision is the first decision most farmers make about a tract of land. Should this land be cropped? If so, with what crop or crop rotation? You can use PA technologies to identify certain areas of the field that are low yielding or unprofitable year after year and remove these areas from production and/or enroll them in government programs, such as the CRP. You can also combine profit maps with other field information, such as soil types, to identify areas suitable for different crops or rotations.

12. Take site-specific soil fertility samples. Both grid and directed sampling are used to describe soil properties for management of variable rates of fertility. Grid soil sampling involves sampling at points on a square grid throughout a field. The grid size used by many PA adopters is 2½ acres. An alternative to grid sampling is directed sampling, which involves dividing a field into regular or irregular management zones based on features such as soil type, topography, or past yield performance. In either system, collect at least five or six subsamples from each cell or zone and mix them into one sample container. When soil fertility data is returned from the soil testing lab, you can enter the data into your mapping program to create fertility maps.

13. Manage subfields. Once fertility maps have been created, you can use them to make spot applications in parts of fields that are especially low in pH or other plant nutrients. This relatively crude application can be accomplished without specially equipped machines. Simply look at the fertility map and try to make applications in the deficient areas. If you have a DGPS receiver and computer, you may be able to increase your accuracy of application by following the cursor on the field map.

14. Adopt variable-rate technology (VRT). Variable-rate management is the continuous adjustment of inputs to match local field conditions. Variable-rate controllers are required on application equipment for automatic control of application or seeding rates in the field. They are used along with a task computer (a laptop PC) and DGPS receiver. In addition, your software must be able to generate application files to control the process.

This phase of PA adoption is perhaps the most costly if you want to develop PA capabilities within your own operation. Even variable-rate seeding will require significant capital expenditures for planter modifications. Perhaps the best approach to adopting VRT is contracting with service providers. We urge you to consider the use of on-farm testing to evaluate what works for your operation. One area that shows promise in Kentucky is the adjustment of soil pH by applying lime.

Reassess

No matter how you delve into PA technology, you must continually reassess the profitability of the PA practices you put

into use. Too often, PA technologies are adopted based on the testimonials of service providers or other producers. Be certain the practices that you adopt result in an improved bottom line. Perhaps the best way to do this is to review yield monitor data as well as your field-level financial records. Also, be cautious when making decisions based on field data obtained in a single season.

PA and the Future

In many ways, PA is in its infancy. Only a few early adopters have more than four or five years of data. New tools are being developed each year. In the future, new sampling techniques will give better information about variation in field fertility. Sensing technology, such as electrical conductivity and near-infrared imagery, could revolutionize field management strategies. Farmers who have several years of historical data will be able to better use these new tools when they become available. That is why it is important to begin collecting data now.

Pitfalls to Avoid

- **Don't expect large returns with minimal energy.** It has been said that PA technology will not make a mediocre farm manager a better manager. It simply provides tools to quantify spatial variation. Users must still follow fundamentally sound management practices.

- **Expect a learning curve.** Be prepared to spend extra time learning to use the technology's software and hardware.
- **Be aware of software and hardware compatibility issues.** Before purchasing any hardware or software, make sure that all components are compatible and that they are compatible with the systems your service providers may be using.
- **Make sure your farm computer has the minimum requirements of random-access memory (RAM) and hard disk space.** Precision databases can become quite large. Plan for a way to back up your data and then keep that backup in a location away from the computer. Don't let a fire or other disaster destroy the originals and the backup.
- **Be prepared to make management changes.** Using PA technology won't increase your profits if all you do is monitor your existing management strategies. You have to make changes to see results.
- **Don't expect results overnight.** It may take several seasons to see and confirm positive results from using the technology. Be patient!

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Lexington, KY 40506 Revised 04-2024



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