Report to the North Central Soybean Research Program

Determining Barriers to Adoption and Research Needs of Precision Agriculture

submitted by

Bill Wiebold, Ken Sudduth, Glenn Davis, Kent Shannon, Newell Kitchen
Missouri Precision Agriculture Center
University of Missouri and USDA/ARS

Introduction

Precision agriculture is an information-based approach to farming that is enabled by a collection of rapidly changing technologies. Although adoption of these technologies has been reasonably rapid, it is not clearly understood how to exploit the full power of precision agriculture. Additional research related to precision agriculture should be needs-based. In other words, we must have a better understanding of what barriers to increased adoption of precision agriculture exist and what is required to move present users to the next higher level. Once these key needs are understood, we can develop appropriate research projects to meet these needs.

There is no better source from which to learn about the needs of technology users than the users themselves. For this reason, we conducted four focus groups across a geographically diverse area within the North Central Region. Our overall objective was to provide the North Central Soybean Research Program with information to help them prioritize their support of research projects related to precision agriculture. To do this we used focus groups to determine the barriers that prevent or inhibit the increased adoption of precision agriculture by soybean producers in the north central region and what information and/or research projects are required to move present users of precision agriculture to the next higher level.

Procedures

We conducted focus groups in four locations within the soybean belt of the north central region of the USA. Dates and location sites were Higginsville, MO on July 16; South Sioux City, NE on July 18; Bloomington, IL on July 21; and Fort Wayne, IN on July 23.

At all locations except Bloomington, two sets of soybean producers were invited to be part of the focus groups. One set of producers was selected to have little or no experience in precision agriculture (non-adopters). This group met in the morning for about 2 hours. The other group was selected to have at least two years of experience with

some aspect of precision agriculture (adopters). This group met in the afternoon, also for about 2 hours. In Bloomington, only the adopters group met.

Names of farmers to be invited were provided by local contacts, typically county or area level extension specialists, and by our cooperators at land grant universities within the north central region. Each person was telephoned at least once and persons interested in participating were provided a letter explaining the project. Mileage and a $100 honorarium were provided each participant to partially reimburse them for their time and effort. Group size ranged from 3 to 9 participants. Observers from extension and Universities were allowed in the room, but were not allowed to participate in the discussion.

Focus group meetings were conducted by a trained facilitator from the Department of Rural Sociology, University of Missouri. The protocol used at all four sites was developed by the facilitators and Ken Pigg (Professor of Rural Sociology, University of Missouri) in consultation with members of the Missouri Precision Agriculture Center. This protocol was designed to meet the objectives listed in the project proposal. Written notes were taken at all focus group meetings and compared to audio recordings.

Written summaries of focus group discussions were sent to each of our cooperators and members of MPAC. These written summaries were used to develop recommended research topics.

Results and Discussion

I. Focus Groups

Gathering information from people with focus groups is widely used in market research. It is used with growing frequency in various kinds of social science research, program evaluation and planning. Using focus groups can produce information quickly, providing information with a high degree of validity to decision makers and researchers. It's use is varied and, at the same time, limited. These uses and the limitations of the method are described below.

A. Validity of Focus Group Information

As with most research activities, data collection efforts that use focus groups are frequently concerned with the validity and reliability of the results. First, focus groups are almost never used in research activities where "statistical" validity and reliability are required. Focus group participants are rarely randomly selected, their confidentiality is difficult to protect, the interaction of focus group participants produces "bias" in the data because each participant responds to the observations and input of other members of the group. Therefore, this form of validity and reliability are impossible to produce using focus groups.

Despite these attributes, focus groups excel at producing information with a high degree of "face" validity. This means that the information collected reflects the understanding of a variety of (usually) well-informed individuals regarding the question placed before the group "in their own words." The participants respond to each other's observations and information, adding to the overall quantity and clarity of the information provided. The researcher, therefore, usually obtains a very complete and accurate picture of the situation "as seen by the participants." The information provided has been discussed and explored to such a degree that all members of the group usually agree upon the final observations, or the nature of any disagreement is fully documented and understood by the researcher, just as it is by the participants. Focus groups are frequently among the most valuable participatory research methods, particularly for "exploratory" research activities.

Reliability, or the ability of other researchers or data collection methods to produce similar results, is rarely possible using focus groups. The interaction of the specific members participating in the focus group, the skill of each group facilitator conducting the focus group, the situational factors that affect comfort, trust and other small group dynamics, cannot be controlled in the same fashion in every group for different researchers. Therefore, it is rarely possible to claim that the results obtained in specific set of focus groups can be reliably reproduced in another set of focus groups by another researcher—the primary test of reliability. Even asking the same questions by the same group facilitator to a different group of participants would not likely produce the same data.

B. Using Focus Groups for Data Collection

The validity is enhanced if the participants are carefully selected to reflect a diverse set of circumstances and experiences related to the research question. Of course, even if the invitation list is appropriately diverse, the researcher rarely knows or can control events that might cause a participant to be absent from the focus group session. Assuming all whom are invited actually participate and are chosen to represent a diverse set of experiences and status elements regarding the research question, the face validity of the data is very high. Decision makers can trust the results and know that they are reasonably accurate "for the participants in that focus group." If several such diverse groups are constituted and skilled facilitators, using the same focus group interview "protocol," conduct each session, the results should be "comparably valid" and trustworthy.

Focus group interviews are generally conducted by a trained and experienced facilitator or researcher. This facilitator is accompanied by another individual who is assigned the responsibility of taking notes about the discussion. The discussion is also tape-recorded so that the notes taken can be verified and anything that is missed in the hand-written notes can be added. These notes are then combined for all focus groups and the text is examined for common themes, ideas, or information that group participants tend to express agreement about or is mentioned frequently. This examination pays attention to those ideas and statements that may be unique; these ideas may contain information as important as that frequently mentioned, but only the decision makers can

decide this. While frequent mention of similar ideas usually indicates some degree of common experience, the singular idea may also be important, representing a significant insight useful to decision makers.

C. Use of Focus Group Information

Unlike statistically valid and reliable surveys for example, focus group data can not be "generalized" to all members of a population under study. In this study, the adopters and non-adopters of precision agriculture techniques, are not randomly chosen and the data collection is not completely in a statistically reliable fashion. No tests of significance are possible for the results. What the participants said in the focus groups can not be considered to reflect the views of all the users of precision agriculture.

Nevertheless, the participants were (supposedly) chosen to participate because they were "lead users." That is, the participants represented a reasonably broad spectrum of the general experiences of all users in an area of the nation where they are located. They have had sufficient experience in farming and with precision agriculture that their information should be reasonable valid and should generally "approximate" the kind of information likely to be found in a statistically valid survey. When combined with other experience and expertise, judgments can usually be produced that decision makers can be confident in using. It must be recognized that decision makers will be using their best judgment based on this information, but they cannot be fully confident that the accuracy or reliability of the information derived from focus groups represents the kind of information that might be assembled from a statistically valid and reliable sample using another data collection method.

II. Obstacles to Adoption and Diffusion of Precision Agriculture Technology

The following obstacles were identified in the focus group interviews of both adopters and non-adopters. No indication is given of which of the seven focus groups the information was taken from, however, the following obstacles are generally ranked in the order of frequency of mention. No "count" of the frequency is provided as this data is very difficult to discern from the tape recorded discussions. Research and development needs are suggestions from the participants and are neither prioritized nor listed in terms of frequency of mention. Following the identification of the obstacle, a short discussion is provided to help decision makers better understand the nature of this obstacle as identified by participants.

A. Cost of Technology Adoption

The "cost" obstacle is composed of several dimensions, including: the investment cost of the equipment, the time involved for producers to learn how to use the equipment and derive the greatest benefit from it, and the length of time it takes to experience any return on the producer's investment. Non-adopters generally mentioned that they were reluctant to purchase the equipment until they were aware that it had dropped in price

significantly. Moreover, they were concerned about obsolescence of both hardware and software. Recent moves by Rockwell strengthen this concern. Until one or two "systems" become dominant, with the bugs worked out, producers will be reluctant to accept high investment costs. Several adopters stated that they were "ahead of the companies" and "that they were the R and D departments" for the various companies.

Both adopters and non-adopters mentioned that the time and expertise needed to learn how to use the equipment and software represented a significant obstacle. Time has several dimensions. Non-adopters were particularly concerned about how long it would take to calibrate and set up equipment like yield monitors, and how well that equipment would work once in the field. Most felt they were unlikely to use the equipment in the field if it didn't work in a relatively short time because they would "lose" the benefits of their investment. In other words, the time investment in precision agriculture is perceived as occurring exactly when farmers have a time deficit, e.g. at harvest or planting times. Cooperatives or other service providers can also have too many producer commitments to perform grid sampling or to provide variable rate applications to farmers in a timely manner – i.e. service providers get "backed up" and sometimes cannot meet their obligations.

While adopters are more likely to accept the steep learning curve in using precision agriculture, both adopters and non-adopters are frustrated that precision agriculture equipment and software are not more "user-friendly." To adopters, this cost was particularly frustrating as several stated that they now had "lots of data" but did not know how to analyze it usefully or that they experienced a great deal of difficulty in getting different pieces of software to work together. Data gathered through precision agriculture appears to have raised as many questions as it has answered for farmers, particularly in understanding the different factors of soil and yield variability highlighted through precision agriculture techniques. The manipulation of data for useful analysis also represents an investment of time.

Another dimension of the cost involved in adopting precision agriculture is that it is very difficult to keep up with rapidly changing technology, particularly for older farmers and/or for those farmers using older hired hands. Producers or hired hands unfamiliar with electronic equipment are unlikely to invest the time necessary for learning how to use precision agriculture equipment. There is also considerable skepticism that precision agriculture equipment and software can actually deliver all the data promised in a useful form. This is particularly important in the face of low commodity prices.

Another factor related to the desire for better cost information is that producers would use this data in their negotiations with landlords to make better financial arrangements in a share-rent agreement. At this point, many renters have not been able to convince landlords of the benefits of precision agriculture in order to share costs with them. Another factor is that some renters are worried that establishing mapping and data for particular farms could cause them to lose out if competitor made a better offer based on information supplied from precision agriculture. However, some adopters have used

information gained from precision agriculture to their advantage in landlord negotiations. For example, several producers used yield maps to prove that additional tile drainage could increase yield. Several other producers use precision agriculture information to negotiate an appropriate lease or purchase price.

Nearly all participants focused on the cost of precision agriculture because these costs were tangible and relatively easy to document. Even adopters found it less easy to document benefits. One participant stated that to be cost-effective, precision agriculture must reduce costs and/or increase yield and asked "where's that information". But, we found no adopters that would "give up" their precision agriculture tools. Several admitted that the information gleaned from using precision agriculture influenced their management and that benefits were subtle, but real.

Perceived research and development needs

- Methods for pulling different data sets together for analysis
- Software for "real-time" decision making in the field
- More reliable financial data on return on investment for adopting precision agriculture
- Reduced costs for precision agriculture equipment
- Simpler calibration procedures and more reliable equipment
- Software integration to assist with decision making and planning
- Standardization of software and equipment systems
- Elimination or reduction in incompatibility among hardware and software systems

B. Training Programs and Consultation Resources

Both adopters and non-adopters indicated they did not have access to sufficient training to make them fully competent in the use of precision agriculture technology, especially the computer software for assembling and managing data and conducting the appropriate analyses. As some participants noted, precision agriculture tools give you a lot of information "but few answers". Other participants indicated they were not able to determine all the factors that might contribute to variability in yields and were not sure that precision agriculture could help them all that much. While "mapping" may be simple enough for many to accomplish and was usually considered valuable, producers wanted to do more with this information. Training needs extended to the use of the technology itself as some participants noted their fears when untrained employees from service providers or older hired hands were using the equipment and the resulting unreliability of the information gathered. Generally, participants noted that precision agriculture use requires a rather steep "learning curve" and the technical infrastructure is not in place to assist them in learning how to use this technology effectively.

Participants also stated that commercial representatives for various input dealers need training in precision agriculture as they are often the most readily available source of information and many are uninformed about precision agriculture techniques and analytical methods. Participants felt there is no really good place to go for help with troubleshooting

various problems with equipment and software. In fact, there appears to be a general perception among adopters that they are way ahead of companies, service providers or university extension in understanding and using precision agriculture techniques.

However, several adopters were pleased with the amount and quality of local technical support. In fact, the presence of a well-informed and active local "expert" was the biggest reason for adoption in a specific area.

Perceived research and demonstration needs

- Establishing large demonstration plots (40 acres) for research, education and training
- Improved operators manuals
- Development of more extensive consultant infrastructure including improved technical abilities of input dealers
- Training seminars where producers can sit down and work through software programs and equipment operation. One-on-one help would be very useful

C. Data Quality Control

Participants indicated that they experienced several areas of difficulty in maintaining good quality data collection. Yield monitors are easily covered with residues. In some areas, location correction signals were available only intermittently. Equipment for soil testing "on the go" was desired by some participants and many indicated they were unsure of the appropriate size of the sampling "grid". Other participants indicated better monitoring of the combine grain flow dynamics was desirable, particularly on uneven ground. More effective grain moisture sensors were desired. Several participants emphasized that they needed better agronomic data (e.g. the response of seed varieties to changes in input variables, moisture and disease resistance). In many instances the causes of yield variation were unknown. Participants also noted they sometimes experienced data loss when transferring information from the yield monitors to the computer used for analysis.

Perceived research and demonstration needs

- Improved yield and soil monitoring equipment
- Improved calibration techniques and ease of equipment use
- Increased agronomic information for producers to use in selecting varieties and managing yield
- Information about weather effects on yield
- Development of simple instructions for data quality control for all aspects of precision agriculture

D. Consumer Guide for Precision Agriculture

Precision agriculture adopters—and non-adopters—desired more information about the comparative advantages/disadvantages of different precision agriculture equipment and techniques, hardware, software and input combinations. This consumer guide should cover all aspects of precision agriculture use in production and management arenas. Criteria should be developed using producer input about different expectations and benefits desired, and all of the related practices, technologies, and inputs should be included. Criteria suggested by focus group participants included performance data (under different management approaches), reliability, data quality, compatibility with different software systems and data formats, ease of calibration and maintenance and cost /benefit analysis.

The consumer guide should also address the conditions of farming for which precision agriculture was likely to have the greatest benefit. That is, if a farm is located in an area where there is little soil variability, the reason why the producer should use precision agriculture should be addressed. The guide could also provide more standardized recommendations pesticide use for different soil types.

Producers in these focus groups indicated they desired an unbiased source for information in this context and that none was perceived to be available currently.

Perceived research and development need

- Develop consumer guide to precision agriculture technology and management approaches

E. Environmental Aspects of Precision Agriculture

An important benefit from precision agriculture (in the long run) that could influence adoption and diffusion may be the documentation of environmental benefits and influences resulting from its use. Participants indicated they wanted to see research that documented environmental improvements without affecting yields. They felt their ability to "prove" they were using the best possible practices would protect them from blame in contributing to non-point source pollution, as well as provide a way to improve their own conservation practices. Several adopters mentioned they used precision agriculture as part of their stewardship of soil resources.

Another dimension of this environmental aspect is precision agriculture's role in maintaining soil health. Some participants noted that their management philosophy focused more on maintaining healthy soils through crop residue management, crop rotation and tillage techniques than "just" fertility. Some participants felt that precision agriculture was targeted too heavily in the area of fertilizer use.

Perceived research and development needs

- Research demonstrating precision agriculture's contributions to soil health as well as fertility maintenance
- Research documenting the impact of precision agriculture use on reduced water pollution
- Documentation of management record-keeping aspects of precision agriculture

F. New Technology Development

Participants discussed several ideas for new research that related to new technology applications. These ideas included the following research and development needs.

Perceived research and development needs.

- Integration of laser and remote sensing technology for spot-treatment of weeds
- Study influence of soil moisture on yield including variable irrigation
- Research on varieties more compatible with precision agriculture
- Development of data cards able to store greater amounts of data than what is currently available
- Development of remote sensing equipment
- Encouraging standardization of equipment design;
- Better targeting of management practices to variable yield goals
- Documentation of appropriate grid size
- Development of equipment that would allow on-the-go soil analysis, both fertility and soil quality
- Basic agronomic work on the relationship between yield and soil properties
- Disease and insect management as related to variable application of other inputs

G. Other Obstacles to Adoption of Precision Agriculture Techniques

Age of operator and size of farm also make precision agriculture adoption more difficult for some producers than others. No consensus from these focus groups on the threshold farm size was formed, this aspect of precision agriculture is clearly site-specific. In addition, older farmers (~60 years or more) are unlikely to make large investments in precision agriculture that will not pay off before they quit farming. The learning curve of older operators also appears to be steeper than for younger producers, particularly for farmers who have not adopted other electronic technology. This is consistent with most work in the adoption/diffusion of new technology. However, most focus group participants – adopters and non-adopters – are convinced that precision agriculture will be widely adopted in just a few years.

III. Other Issues

Some participants were concerned about the ownership of the data collected by service providers. Farmers consider the data from their farm to be their own and want this to be clearly understood. They were also concerned about the dissemination of their data, especially if names and locations are traceable.

Moreover, data ownership becomes central in landlord/tenant relationships. If tenants take the time to build complete data sets for certain farms, they prefer long-term relationships with those landlords – i.e. they don't want to lose that farm to another renter who has access to the farm's data. Some, although certainly not a majority of the participants, were concerned that precision agriculture techniques can allow for managing of farms from afar and that might lead to more "corporate" farms. They were concerned that they would be forced to buy all inputs from a single provider. At the same time, producers are also interested in seeing how they can pool information collected using precision agriculture techniques to help them be better farmers.

Several participants stated that soybean check-off funds should be spent on finding new uses, specifically domestic uses of soybeans, and not on production research.

On the whole, participants are mostly convinced that precision agriculture techniques are useful management tools, particularly in spotting variability in soils and yields on farms, reducing chemical inputs, testing seed varieties on farm, and improving farm record keeping. Most focus group participants predict the widespread adoption of at least some precision agriculture techniques in the next few years.

Recommended Research and Education Priority Topics for Precision Agriculture

Precision agriculture is an appropriate area for investment of soybean check-off dollars. Actually a collection of emerging, and in many ways diverse, technologies, precision agriculture provides information that is essential to the development of cost-effective soybean-cropping systems that limit impact of agriculture on the environment. Use of farmer generated funds ensures that information about precision agriculture will be readily available to producers. This information is essential to appropriate decision making.

Our focus group discussions focused on the barriers to increased adoption of precision agriculture. Many of the perceived barriers are characteristic of adoption and diffusion of any new technology. Some of the identified barriers do not lend themselves easily to research or demonstration projects. Other barriers are researchable topics, but beyond, in our estimation, the scope of the NCSRP.

We used the information gained from focus group discussions and that provided by our science advisory board to develop suggested actions. We recommend that both research and education projects be solicited.

As pointed out in every focus group, the use of precision agriculture generates abundant amounts of information. It is natural that precision agriculture users desire software that analyzes this abundant information and generates management recommendations.

We strongly believe that our understanding of the causes of yield variation is incomplete. And, that before models can be developed we need a better understanding of soybean yield limiting factors. Precision agriculture is not only used by farmers, but is an excellent tool to be used in research investigating yield limiting factors. As our knowledge of yield limitations increases we can better develop management strategies.

Suggested action 1: Solicit research proposals that use precision agriculture tools and focus on identification of soybean yield limiting factors and the manner in which they relate to yield variation within fields.

Focus group participants correctly identified "soil health" or soil quality as critical to soybean yield. Unfortunately, our ability to characterize these soil properties in a rapid and cost effective manner is limited. Soil surveys are useful, but are too general and often do not provide essential information.

Suggested action 2: Solicit research proposals that increase our understanding of soil quality and relate these properties to soybean yield in a site specific manner.

Suggested action 3: Solicit research proposals that develop "on the go" sensors for appropriate soil properties including but not limited to soil structure, bulk density, and fertility.

Requests for a "consumers guide" are surely understandable, but development of this guide is likely to be beyond the scope of NCSRP. Such a guide would be expensive to produce and maintain. Technology is moving so quickly that information in the guide would suffer the same obsolescence fate that focus group participants feared for their purchased software and hardware. A better course of action is supporting on-going activities aimed at standardizing precision agriculture testing and systems. Improved standardization would reduce the fear of obsolescence, make comparisons of competing systems easier, and improve compatibility among controls for various farm implements and precision agriculture systems.

Suggested action 4: Support the efforts of the American Society of Agricultural Engineers and the Agricultural Electronics Association in developing standards for hardware and/or software compatibility and for uniform product evaluation procedures.

Several focus group participants discussed the role of precision agriculture in limiting the impact of crop production on the environment. They use precision agriculture as part of their stewardship of soil. Other discussion focused on the record-keeping ability of precision agriculture and that these records may be important in liability issues. Investment of farmer generated funds in environmental aspects of precision agriculture is good science and good politics.

A specific area of environmental concern is the application of animal waste. In the past application of manure to crop land has not been uniform and has caused some of the observed variation in fertility. Nutrient management aspects of precision agriculture are especially suited for overcoming this variation and helping with safe disposal and use of manure.

Suggested action 5: Solicit research proposals that study the interaction of livestock manure application, soybean growth and yield and determine how this information can be used in site specific application.

Education and training activities are essential for increased adoption of precision agriculture. Present adopters have sought out or self-generated the information they needed. But, widespread adoption depends on sustained education programs. Some participants suggested large scale demonstration sites. Although these demonstration sites would be effective, we believe that, if done correctly, this effort would be too expensive.

Suggested action 6: Solicit producer education proposals. These proposals should include both written documents (perhaps a regional guide) and face to face training schools.

The presence of a competent local source for technical information was identified as nearly essential for increased adoption of precision agriculture. Local dealers for all crop inputs (not only precision agriculture suppliers) can be part of a precision agriculture information network.

Suggested action 7: Solicit dealer education proposals. These proposals should include training exercises in electronic format (e.g. CD ROM, world wide web).