Information Requirements for Precision Farming: The Next Decade

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Information requirements for all phases of agriculture are changing very rapidly. Much of this change is being driven by technology and a focus on "precision farming" which is a current buzz word among agricultural circles. The term "precision farming" means using the best available technologies to tailor soil and crop management to fit the specific conditions found within an agricultural field or tract. Precision farming is sometimes called "prescription farming," and "site specific farming" and includes "variable rate technology." It has caused a resurgence of interest in remote sensing in addition to a reliance on geographic information systems (GIS) and global positioning systems (GPS).

All three technologies have been used intensively by NASA and the Department of Defense. Since Desert Storm, where GPS was demonstrated to have many practical uses, the technology has been readily adapted by agriculture for use in all phases of production. We have the opportunity to literally take "agriculture into the space age" with these technologies. Farmers will have services available to them that involve satellites collecting data, transmitting locational information, or providing data from a variety of other sources. Farmers can 1) analyze this satellite information with their own equipment, 2) rely on consultants to analyze and interpret the data for a fee, or 3) become associated with a company which provides the analysis as a service to insure retention of the farmer as a customer for other business.

Some farmers have already experienced the benefits of remote sensing data. Images from Landsat and SPOT satellites and aerial photography have been used to distinguish crop species and locate stress conditions. However, the cost and timeliness of obtaining the images have been the biggest deterrents in regular use of such data. The increased price of corn and soybeans during the 1996 growing season has caused farmers to explore opportunities for making more money per acre. Similarly, the recent government approval to use high-resolution images has allowed more practical applications of remote sensing to high-value, low-acreage crops.

We predict that future satellite launches, including those from Space Imaging, the TRW Small Satellite, World View Imaging, Resource21, EarthWatch and GER, will be competing for the agricultural market with resulting value-added products specific to the needs of farmers, and we expect that reasonable prices will encourage farmers to participate. The remote sensing aspect of precision farming will need to be proven; it has been tested during the past few crop years by university, government and commercial researchers with a renewed interest of better spatial resolution and timeliness of delivery. Everyone is trying to determine what one can see using remote sensing information and to establish a quick way of getting the information to the farmer.

More attention is being paid to the type of information that farmers will need. It would appear that most remote sensing vendors will not be delivering raw images directly to the farmers. Rather they will provide data/information to the "informati

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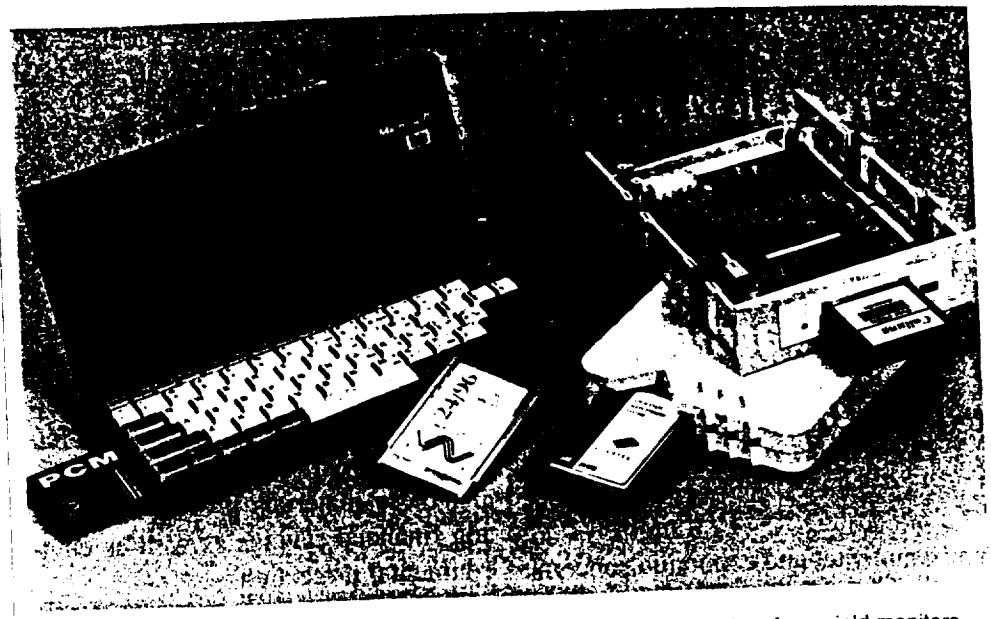
multipliers" or the "value-added vendors" such as agricultural business dealers, extension personnel, crop consultants, and special agricultural information services who in turn will analyze and interpret the data and deliver it to the farmer. Farmers are collecting a lot of supporting data and those analyzing the remote sensing data will need to gain access to the farmer's data. Large corporate farmers will be in a position to perform their own image analysis but we must remember the needed training aspects for this to be successful.

Farmers have recently gained access to site-specific technology GPS. GPS makes use of a series of military satellites that can identify the location of farm equipment within one meter of an actual site in the field. Knowing a precise location within inches has many valuable consequences: 1) locations of soil samples and the laboratory results can be used to prepare soil and yield maps, 2) fertilizer and pesticides can be prescribed to fit soil properties (texture and organic matter content) and soil conditions (relief and drainage), 3) tillage adjustments can be made as one finds various conditions across the field, and 4) one can monitor and record all of this data as one moves across the field.



Envoy Data Corporation's PCMCIA products for microcomputers allow data from yield monitors and GPS systems to be downloaded. Systems supported are John Deere, AG Leader, Case IH, Micro-Trak, SATLOC, and others. The Envoy product catalog is available on the Internet at http://www.envoydata.com

Other real values for the farmer include the ability to perform more accurate crop protection programs, provide more timely tillage, adjust seeding rates, and know the yield variation within a field. These benefits, if achieved, will enhance the overall cost effectiveness of the farmer's crop production.

Crop Management

The application of pesticides and fertilizers in proper proportions are of

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environmental and economic concern. Environmental regulations are calling for the discontinuance of certain pesticide applications within a prescribed distance of a stream, waterbody or well. Using a GPS along with a digital drainage map, the farmer is able to apply these pesticides in a more precise and economically sound manner. In fact, the spraying equipment can be preprogrammed to automatically turn off when it reaches the distance limitation or zone of the drainage feature. Additionally, farmers can preprogram the application rate of pesticide or fertilizer so that only the amount needed as determined by the soil conditions is applied, thereby allowing a variable rate from one area of the field to another.

Soil sampling has taken on new interest for many farmers since they can now adjust rates according to the test results. The more accurate the sampling, the more accurate the final management plan will be.

Much work is needed regarding the proper sampling patterns, the relationship of a soil test value to the actual conditions of the field, the proper depth of sampling, interpretation of results to the specific geographic location, innovative equipment for properly applying chemicals and fertilizers and many other factors. The farmer is looking at methods of applying these materials properly, providing financial savings as well as environmental protection.

Understanding the Soil Conditions

The ability to vary the depth of tillage as soil characteristics vary is important to proper seedbed preparation, control of weeds and fuel consumption, and therefore can reduce the cost to the farmer. Most farmers are using conservation tillage, or leaving residues on the soil surface for erosion control. The use of GPS in making equipment adjustments as one travels across the different soil types would mean higher yields and safer production at lower cost. This part of precision farming is in its infancy.

The equipment companies are announcing tillage equipment with GPS and have selected controls tailored to precision farming. Implement manufacturers, while wanting to accommodate farmer needs, are not really interested in major changes in the tillage equipment because of the costs of redesign, production and marketing. However, to remain competitive, it will be necessary to do so.

Seed Selection and Placement

Hybrid seeds perform best when placed at a spacing that allows the plants to obtain such benefits as maximum sunlight and moisture. This is best accomplished by varying the seeding rate according to soil conditions, such as texture, organic matter and available soil moisture. One would plant fewer seeds in sandy soil as compared to silt loam soils because of less available moisture. The lower seed population usually has larger heads (ears) of harvested seeds providing for a maximum yield. Since soils vary even across an individual farm field, the ability to change seeding rates allows the farmer to maximize this seeding rate according to the local conditions. A computerized soil map of a specific field on the GPS-equipped tractor can tell farmers and their equipment where they are in the field, allowing the opportunity to adjust this seeding rate as they go across their fields.

Recent results by major seed companies and universities show that with present varieties, only a minor yield gain can be achieved by adjusting

seeding rates. This likely points to companies breeding for a wide range of climatic conditions for greater adaptability over a larger geographic area, thereby making a profit from a specific variety. This is likely to change in the future as farmers start to demand seeds for specific conditions.

Yield Variation

The proof in the use of variable rate technology (adjusting tillage, seed, pesticide and fertilizer) as one goes across the field is in knowing the precise yields. Combines and other harvesting equipment are being equipped with weighing devices or pressure plates that are coupled with a GPS. One literally measures yield "on the go." With appropriate software, a yield map is produced showing the variation throughout the field. This allows farmers to inspect the precise location of the highest and the lowest yielding areas of the field and seek to determine what caused the yield difference. It allows one to program cost and yield to determine the most profitable practices and rates that apply to each field location.

The use of yield monitors is a good place to begin if one wants to incorporate precision farming into their management. With a yield image, one can begin the search for what caused the high and low yields. It also helps familiarize farmers with imagery for an easy transition to remotely sensed images. Yield data from the same field over 3+ years would define the weak spots in the field and narrow down the probability of what is causing a low yield.

NovAtel's PC Performance 3900 Series features a 2/3 length personal computer card designed for installation in PC compatible computers. This card allows integrators to provide accurate GPS functions in computer applications such as precision agriculture, GIS, mining, navigation, robotics and surveying.

Information Requirements of the Future

GPS has already made a big impact on how farmers are viewing their farming operations. Now they are able to collect data, apply chemicals/nutrients, make observations and collect yield data at precise locations in the field. Where do information systems fit into farming in the next decade? They will be essential to nearly all operations on the farm.

Several companies are starting to market GIS record-keeping systems so farmers can record all of the field operations such as planting, spraying, cultivation and harvest (along with specific information such as type of equipment used, rates, weather information, time of day performed, etc.). In the very near future, this will occur automatically from GPS-based systems. Additionally, using remote sensing, farmers are able to record observations through the growing season such as weed growth, unusual plant stress or coloring and growth conditions. All of these data can be analyzed and added to the GIS using soil maps, digital terrain and field operations information as ground truth.

Precision farming can be used to guide additional field operations like spraying, fertilizing and irrigating. This also provides a permanent record on which to base management decisions . Precision farming will make a strong impact on the way farmers manage their farm operations in the future. We will see a steady growth of the remote sensing, GIS and GPS technologies as a result of the momentum already gained through the precision farming emphasis. AT